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THE PHYSICAL LABORATORY AND ITS CONTRIBUTIONS TO CIVILIZATION

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ALTHOUGH physics is one of the oldest and most respectable of the sciences, it must be acknowledged with regret that many otherwise well-educated persons have but a vague idea of its scope, and the question, "What is a physical laboratory and what does one do in it?" is by no means a rare one. The science of physics or natural philosophy, as it was called by Newton, properly includes the study of all natural phenomena that are not concerned with life, as distinguished from biology, which undertakes to investigate the phenomena of living organisms. To speak more particularly, physics deals with mechanics or the phenomena of motion and its causes, including those motions which we characterize as sound; with heat, light, electricity and magnetism and those new phenomena which have to do with radio-activity and the recently discovered new sorts of radiation. It is thus impossible to make any classification of physics which shall exclude astronomy, which is divided into celestial mechanics or the study of the motions of the sun, planets, comets and stars, and the new science of astrophysics, or the study of the physical and chemical constitution of the stars mainly by means of the spectroscope invented only about fifty years ago, or which shall exclude chemistry, which now more than ever before is concerning itself with the relations of different elements and their compounds to phenomena of heat, electricity and light. Geology has mainly to do with the applications of physics to the surface of the earth. Nevertheless, for purposes of convenience it has become customary to divide off these other sciences from physics proper and to have them studied and taught by separate professors.

If we examine the history of physics we shall find that this division

came very late, perhaps not much more than one hundred years ago. The first physical phenomena to be studied were, undoubtedly, those of day and night, the rising and setting of the sun and moon, and the changes of the seasons. We know very well that a people as highly cultivated as the Greeks, although they were deeply interested in natural phenomena, had an extremely small knowledge of the laws of nature and had not learned how to investigate them. Although they possessed an excellent knowledge of geometry, they had not the slightest idea of the nature or laws of motion, whether celestial or terrestrial, and with the exception of the properties of the lever and of liquids at rest, known to Archimedes, their knowledge of physics was almost a blank, and yet their great philosopher, Aristotle, dominated science until the sixteenth century of our era. It was at this time that the dawn of modern physics took place with the beginning of the experimental study of nature by Galileo. We must remember that Aristotle suffered not so much from lack of knowledge as from lack of appliances. What might he not have discovered had he possessed a thermometer, a telescope or even a clock! Nevertheless, Galileo did not possess these simple instruments, but he went to work to make them possible. He invented the telescope and thus made possible the searching of the mysteries of the heavens. Although he had no clock, he studied the motions of the pendulum, formed by the great lamp in the baptistery at Pisa, by comparing the time of its swing with the number of beats of his pulse, thus making possible the application of the pendulum to clocks by Huygens. As a contrast of Galileo's method with that of the Greeks may be cited his experiment of dropping a light and a heavy body from the top of the leaning tower of Pisa and showing that both fell to the ground at the same time, instead of believing, as the Greeks had done from reasoning without experiment, that the heavy body falls the faster. By careful study of the motions of a ball rolling down an inclined plane, Galileo was able to enunciate the precise law of falling bodies; that their acceleration is uniform, that is, that in equal times their velocity increases by equal amounts. The way was thus prepared for Newton, who in the next century established the connection of all forces with the accelerations produced by them and was able to enunciate the laws of motion, both terrestrial and celestial, in a form that has not been improved upon to-day, constituting one of the most magnificent triumphs of the human intellect. Passing on rapidly we find at the beginning of the nineteenth century the phenomena of electricity beginning to attract the attention of investigators, while those relating to light had already made substantial progress. All this time there had been nothing that could properly be called a physical laboratory. Discoveries had been made by individual inquirers working generally in such rooms as they had in their own houses with the most meager facilities. We all remember how Newton bored a hole

in the wooden shutter of his window in order to admit a narrow beam of light which was to be dispersed into a spectrum by his prism. Even as late as the middle of the nineteenth century the celebrated determination of the velocity of light was made by Foucault, who is said to have been so poor that he was obliged to hire a pair of telescopes at an optician's and to make the experiment in his own rooms. In fact, physical research had reached a very great extension before the provision of special buildings in which to carry it on had been thought of, and these were first provided in connection with instruction. It was not until 1874 that the celebrated Cavendish laboratory was completed at the University of Cambridge, and it is worth remarking that this great laboratory, out of which has proceeded a large number of the most remarkable modern discoveries in physics, was built at a cost of little over $40,000. It is interesting to know that the introduction of laboratory studies at Cambridge was attended with much shaking of heads and it seemed necessary to Maxwell, the first professor of experimental physics there, to justify its introduction in his opening lecture. "But what," he says, "will be the effect on the university, if men pursuing that course of reading which has produced so many distinguished wranglers turn aside to work experiments? Will not their attendance at the laboratory count not merely as time withdrawn from their more legitimate studies, but as the introduction of a disturbing element, tainting their mathematical conceptions with material imagery and sapping their faith in the formulæ of the text-books?" A more amusing doubt was that expressed by Todhunter, himself a distinguished mathematician and student of natural phenomena. "What is the use," said he, "of a student's confirming a physical phenomenon by an observation in the laboratory? If he will not believe the statement of his tutor, who is presumably a gentleman of exemplary character in holy orders, what use can there be in his repeating the experiment for himself?" It is needless to say that this point of view has long since passed into oblivion and the strong point of the laboratory is that it enables the student to himself verify the laws of nature quite independently of the statements of any authority whatever, however respectable.

The purposes of our laboratories then are twofold. First, in them we teach our students the use and manipulation of instruments and the methods for the precise verification of physical laws. In this way the student becomes accustomed to habits of accuracy and the reporting of what he actually sees without the aid of the varnish of imagination and unaffected by any prejudices as to what result he expected to get. We thus have an education in morals which is hard to equal in any other part of education. As a simple example let us consider the method in which the student studies the motion of the pendulum in the elementary laboratory. Instead of measuring the time of its swing by his

pulse beats in the manner of Galileo, he compares it with the beats of an accurate astronomical clock, which he perceives by his ear while with his eye he notes the passage of the wire which supports the ball of the pendulum across an accurate mark, thus being obliged to use the senses of sight and hearing at the same time. He must then measure the length of the wire accurately as well as the diameter of the ball which hangs from it. Later on, as there will be difficulty in telling where the string or wire ends, more refined means must be adopted for defining and measuring its length. From the results of these measurements the student will by means of theory be able to calculate the result expressing the intensity of gravity and as he presumably knows the correct value, he will be under a certain temptation to so "doctor" his results as to make his work seem accurate. It is needless to say that such doctoring can never be tolerated and is totally incompatible with the character of a true scientist. The example which I have given shows the nature of almost all the work that is undertaken in the physical laboratory. In every experiment certain data are taken which enable us to give a numerical measure of the properties of certain bodies, or a statement of the numerical relations involved in phenomena. As an example we may take the question of the determination of the specific heat of bodies, that is to say, of the amount of heat required to heat a body through a certain range of temperature. For this purpose the body, say an iron ball, is heated to a certain definite temperature, let us say by being immersed in the steam of a boiler in which water is boiling. The ball is then dropped into a vessel containing a known quantity of water and the heat that it gives out in cooling is measured by the rise in temperature which the water undergoes. This apparently simple process is found to be attended with a great deal of difficulty. In the first place, the determination of the temperature of the ball, when in the steam boiler, is no easy matter. A thermometer immersed in the steam as near the ball as possible may not show exactly the temperature of the ball. Secondly, if the stem of the thermometer is entirely immersed in the hot steam the temperature shown would be different from that when only the bulb of the thermometer is in the hot steam and the stem in the cool air. Thirdly, it will be difficult to transfer the ball from the hot steam to the cold water so quickly that it will not have lost some of its heat, which we want to measure, before it gets into the water. Fourthly, as soon as the temperature of the water in the calorimeter, as it is called, begins to rise the calorimeter begins to lose heat by radiation to outside bodies. In order to estimate this we must first study the laws of such radiation by allowing water previously heated to cool in the calorimeter and observe how rapidly its temperature falls. Finally, it is necessary to know accurately how much water was in the calorimeter, which is found by weighing, but during the

whole experiment water is being lost by evaporation. When we consider all these corrections that must be carefully made as well as the fact that to accurately read the height of the mercury in the thermometer it would probably be necessary to look at it with a telescope, the difficulties in this simple experiment and the temptation to slight something are very apparent, and yet this is what we expect a freshman to do in the time of about two hours in the laboratory, and at the same time we expect his result to have an accuracy considerably better than one part in a hundred.

The second and in many cases far more important function of the laboratory is to serve as a place for the performance of accurate research, that is, the investigation and discovery of new phenomena. In order to take part in this inspiring occupation it is obvious that the student must have acquired a considerable amount of proficiency and have already made measurements of a great variety involving a high degree of precision. It is often supposed that scientific discoveries are attended with a large amount of luck, or that they are the result of a sudden inspiration which may come to anybody. Such is far from being the case. Professors of physics are frequently the recipients of visits from persons who in their enthusiasm feel that they have made an important discovery, which in many cases has been thrown off as a sort of by-product in some other vocation. Not many years ago I received a visit from a young man who had traveled over two hundred miles to present to me the results of a theory which he had elaborated to account for the motion of rotation of the planets on their axes. After I had inquired whether he had made himself familiar with the writings of the great masters in celestial mechanics, and had explained to him the impossibility of his theory, I asked him this question, "Do you realize, my dear sir, that if your theory were correct, it would upset the consequences of all the astronomical observations that have been made during the last two hundred years?" The young man went away sadder but wiser and I did not hear from him again. As a matter of fact discoveries are seldom made by persons not possessing the training that I have described, and in ninety-nine cases out of a hundred the element of chance is reduced to the smallest possible dimensions.

I have already stated that the provision of great physical laboratories in connection with instruction is extremely modern. In England the pioneer work in systematized instruction was done in Oxford and London about 1867. The Clarendon Laboratory at Oxford was built from 1868 to 1872, while the Cavendish Laboratory in Cambridge was, as has been stated, not opened until 1874. In this country the first systematic laboratory course in physics was organized about 1870 by Professor E. C. Pickering, at the Massachusetts Institute of Technology, which illustrates one of my points that I have already made, for Professor

Pickering has now been for about thirty-seven years the head of the astronomical observatory at Harvard. The present physical laboratory at Harvard was built in 1884. Of late years laboratories have been built at all our colleges, and there has developed a tendency to make them very large and costly. Two of the latest, the Palmer Laboratory at Princeton and the Sloane Laboratory at Yale, have gone well beyond the quarter of a million mark. The largest and best equipped laboratory in the country is that belonging to the national government, and known as the Bureau of Standards, which, in its brief history of about ten years, has had over two millions of dollars spent upon it. When we consider that this institution is entirely separated from teaching, we must believe that work of great importance is done there to justify this great outlay. Permit me to describe what some of the functions of such a laboratory are, and incidentally to explain some of these devices that are to be found in any great modern laboratory.

At the Bureau of Standards we find five large buildings, each devoted to a particular purpose. These have cost $712,000. In the largest we find the divisions of weights and measures, of heat, and of light. The chief objects of the Bureau of Standards being necessarily practical, the researches undertaken there are limited in scope by this consideration. Nothing is perhaps more practical than the verification of the standards of weight by which commodities are bought and sold. Even the weights of the mint are tested at the Bureau of Standards. Accordingly in a basement room mounted upon heavy brick piers, which are a prominent feature in every physical laboratory in order to secure freedom from vibration, we find extremely accurate balances, some of which are capable of weighing a body with an accuracy of one part in fifteen or twenty millions. The comparison of two equal weights is probably susceptible of greater accuracy than any other physical operation. It is to be remarked that in order to attain this degree of accuracy the balance has to be operated in vacuo, the whole instrument being placed in a case from which the air is pumped out, and all operations of transferring the weights being conducted from a distance by means of controlling rods or shafts, since the heat of the observer's body near the balance would so change the length of the beam as to render such an accuracy impossible.

Next to weighing comes the measurement of length, which is susceptible of about the same accuracy. Here again, the effect of changes of temperature in causing metal scales to expand has to be provided against, so that the work has to be carried on in a subterranean vault, where the changes of temperature are made as small as possible. In the division of heat great practical importance belongs to the measurement of temperatures. Thousands of thermometers of all sorts are sent here yearly to be tested. Before the existence of the Bureau of Standards

there was no official means of verifying the accuracy of clinical thermometers used by every physician in diagnosing disease. Here these thermometers are placed, perhaps a hundred at a time, in a bath of water whose temperature is controlled, by thorough stirring, to an equality of temperature of less than a hundredth of a degree. Of great importance is also development of a means of measuring high temperatures, such as those of red or white heat, at which glass would melt. For these high temperatures it is necessary to use a thermometer-bulb of platinum or some more infusible metal, and filled, instead of with mercury, with some gas. For practical purposes, such as the determination of the temperature of furnaces for porcelain, or for the treatment of steel or the annealing of glass, the temperature may be measured by the comparison of the color of the light emitted by the substances in question with that of a filament heated by a known electric current.

In the division of light one of the most important practical matters is the measurement of the intensity of sources of light, particularly of incandescent electric lights, for when one pays a certain amount he desires to get the largest amount of light possible for his expenditure. It is of interest to know that the amount of light obtained for a certain amount of electrical energy has been increased at least ten times in the last few years by the introduction of the filament of the metal tungsten instead of carbon. Another matter of practical importance in the division of light is the determination of the action of quartz crystal and other substances in twisting the so-called plane of polarization of light, since by this property the strength of sugar solutions is measured, and by such tests the rate of duty is fixed that sugar shall pay.

Two large buildings are devoted to electrical and magnetic research. The enormous development of the production of electricity, whether for light, power or transportation purposes, has rendered the exact specification of its standards of measurement of superlative importance. For over forty years such researches have been carried on in many countries, with ever-increasing precision, but still with certain small discrepancies between the determinations of different national laboratories. For instance, the unit of electric current is practically defined by the weight of silver that it will deposit from a solution in a given time. Owing to the discrepancies in the values obtained, the happy idea occurred to Dr. Stratton, the director of the Bureau of Standards, of inviting the national laboratories of England, France and Germany to send each a delegate to the Bureau of Standards in Washington, where each would carry on measurements by his own methods on the same current traversing all the instruments, thus the discrepancies were much reduced and physics was made to contribute to international good feeling. Besides these researches to establish the standards, which we have already seen to be necessary in heat,

light and electricity, many tests are required on the properties of materials, such as the magnetic properties of iron that is to be used in dynamo-electric machines. All engineering is but applied physics, and a whole building has been devoted to the testing of materials used in engineering and in manufacturing, such as the strength of steel and iron, of concrete, and other materials used in construction, of thread, paper, leather and textile manufactures. It is known that the government buys all its supplies on specification, and for many of the bureaus the testing is carried on at the Bureau of Standards. In addition the Bureau has two branches, one at Pittsburgh, for testing structural materials, and one at Northampton, Pa., for testing cement, where all the cement used in the Panama Canal is tested. It is easy to see how under this rigid testing many improvements of importance to manufacturers are developed, and in this way industry is largely promoted. In fact the bureau is now of as much interest to manufacturers and engineers as it is to physicists.

I have now said enough to show the direct practical importance to the country of a laboratory in which testing, as well as research, is done, even though no teaching is done there. But when I speak of contributions to civilization I do not by any means limit myself to the increase of human comfort, and to the increasing of the production of wealth. Neither do I consider this as the main object of science, nor its chief justification, although it is one that is most easily apprehended by all intellects. Science does not consist in the observation and classification of facts that are useful in this narrow sense, but rather in the fitting of them into a great and harmonious system, that convinces us of the reasonable scheme of nature, and gives us the same esthetic pleasure that the performance of a great piece of music affords, and lifts our spirits to the contemplation of the author of that great scheme of nature, of which, however much we learn, an infinitely greater amount remains for us still to explore. It is only to those who have personally wrestled with nature in the attempt to make her yield up her secrets that this highest aspect of science is revealed. Fortunate are those who, untrammeled by practical ends or the hope of gain, can devote their lives to the calm, undisturbed questioning of nature, and such should our college professors be. It is not yet generally understood that professors should be paid such salaries that they may take this high view of their calling, without being disturbed and in a large degree prevented from fulfilling these highest duties by the struggle for existence.

I shall now, having described some of the objects and means of research in physical laboratories, attempt briefly to trace the history of one or two notable discoveries of the last quarter of a century, with the results of which at least the public is in a large measure concerned. One hundred years before the present time, almost all that was known of

electricity was embraced in the knowledge obtained by the Frenchman Coulomb regarding the law of force with which electricity at rest upon conducting bodies attracts and repels other electricity. Nothing was known of the phenomena of electricity in motion, flowing, as we say, in a current. It was not until 1827 that the law stating the dependence of the strength of the current on the driving-power of the battery causing it was discovered by the German Ohm. But a fundamental discovery was made in 1820 by the Dane Oersted when he found that the current in a wire would act upon a magnet anywhere in its vicinity, or would produce what we now call a magnetic field. Upon this discovery depends the possibility of all our telegraphs, for which the current was soon utilized. But a more powerful intellect than that of Oersted, namely that of the Frenchman Ampère, inspired by Oersted's discovery that a current acted like a magnet, reasoned that in that case two currents would exert magnetic forces upon each other, and in a wonderful series of researches determined the mathematical laws of these mutual actions of currents in the most complete manner. When we see the primitive apparatus with which Ampère made these brilliant discoveries, we are led to have the most profound admiration for his brilliant experimental and mathematical genius, and we may secretly wonder whether we have not laid too much emphasis to-day on fine laboratories and equipments. The next commanding genius that appears on the scene, whose work is more important than any of those yet mentioned, is Michael Faraday, professor at the Royal Institution, a laboratory for research and popular lectures, founded by our own countryman who later became Count Rumford, but made forever famous by the discoveries there made during a long term of years by Faraday. Those who have visited the laboratories at the Royal Institution will be surprised at the total lack at that time of all the conveniences that we to-day expect, but Faraday was no doubt perfectly satisfied with it. To-day electric lighting and supply of current in a laboratory is a commonplace—then there was not even gas, and all currents had to be made by batteries laboriously filled with chemicals for each time of use. There was no insulated wire, and Faraday had to wind his own with thread or ribbon. Among the greatest triumphs of Faraday was his discovery of the converse of the production of magnetism by electrical current; I mean the production of current by magnetism. After long attempts, he found that if a magnet was moved into, out of, or in the neighborhood of a coil of wire forming a complete circuit, then a current of electricity was induced, as he put it, in the coil during the motion of the magnet. This is the germ of our dynamo-electric machines which to-day supply all the current for our light, power and electric traction. Could Faraday have seen the huge dynamos of ten thousand horsepower each that convey the power of Niagara Falls to regions a hun-

dred miles away, he might feel the enormous importance of the work that he had accomplished to the world at large, but I much doubt whether he would have felt a more lively satisfaction than when he first saw the electric spark jump between the ends of his coil surrounding the magnet. The chief question which interested Faraday during the greater part of his life was the question of action at a distance. How can the motion of a magnet or what amounts to the same thing, the change of current in one coil, cause a current to flow in another coil in a different place. This he explained by some change in the medium surrounding the coils, but it was reserved for another to give the complete explanation. This was Clerk-Maxwell, of whom I spoke at the beginning, who was the chief expounder of Faraday's views, to which he added and which he made precise by his wonderful ability to put them into mathematical form. It was Maxwell's brilliant idea that the medium which is affected by the presence of an electric current is nothing else than the ether which is supposed to convey the waves of light, and it was a result of his theory that the electric and magnetic actions are transmitted through the ether in the form of waves. Not only this, but he showed that the velocity of these electromagnetic waves would be exactly that of light. He then made the startling generalization that light waves possess all the characteristics of electromagnetic waves, and in fact differ from them in no essential way. These ideas of Maxwell, first put forward nearly fifty years ago, have now found universal acceptance, and the whole world believes that light is an electromagnetic phenomenon. But it was a long time before Maxwell's ideas were accepted, especially on the continent of Europe. For Maxwell died in 1879 without ever having demonstrated experimentally that electric and magnetic effects are propagated in waves. This was reserved for another, the German Heinrich Hertz, who in 1887–88 was able to demonstrate the propagation of such effects with a definite velocity, which was found to be indeed the same as that of light.

Hertz's first experiment by which this discovery was made was so simple that it may be described. If we have two metal spheres near enough together a spark will pass between them if they are electrified, but only if the electrical potential or pressure is different for the two balls. If the two balls form the ends of a circuit of wire, the whole may be electrified as strongly as we please with never a sign of a spark passing between the balls, for the whole conductor has the same potential. But Hertz found that if the wire, in the form of a rectangular circuit, was connected with one of the ends of an induction coil producing sparks, each time that a spark passed from the induction coil a spark also passed between the balls of the rectangle. This was always supposing that the connection was made to a point of the rectangle not symmetrically placed with respect to the balls, and Hertz explained the

phenomenon by supposing that the current flowed in both directions in the form of a wave, taking longer to go to one ball than to the other, so that there would be a difference of potential between the balls, and hence the spark. This was corroborated by the fact that when the connection to the induction coil was at a point symmetrical to the two balls, there was no spark, for then the wave arrived at both balls simultaneously. This experiment was the first to show the propagation of electric current in the form of waves, and Hertz calculated the time of such a wave running back and forth in the wire as the one-hundred-millionth of a second. The possibility of making such rapid oscillations opened up a whole new field of research, which has been greatly exploited in the last twenty-five years. Not only did Hertz show that the current in a wire was propagated in waves, but he also showed that the electromagnetic effects which are able to induce currents in other wires are also propagated across free space in waves. These waves traverse various obstacles, and are stopped only by conducting bodies. Many persons undoubtedly had the idea that these waves traveling through space might be used for signalling purposes, but it was due to the patience and pertinacity of Guglielmo Marconi that these waves, sent by Hertz a distance of a few score feet, might travel across the Atlantic Ocean and still retain the power of exciting a current in a wire properly set up to receive them. It was only in 1895 that Marconi first began his experiments on electric waves, and in the short time of seventeen years wireless telegraphy has become so important to commerce, not only in connection with the reception of intelligence from ships in distress, but for overland communication in certain remote regions of the earth that last summer a conference was held in London where representatives of over forty nations met to negotiate a treaty for the regulation of wireless communications at sea. I had the honor of being a delegate of the United States government to this conference, and during the five weeks of our proceedings, noting the caliber of the delegates sent by the different governments and the seriousness with which every detail was threshed out in the most diplomatic language, I became vividly impressed with the importance of wireless telegraphy to civilization, and again I thought of the work of Faraday in 1830, Maxwell in 1864, Hertz in 1887, as crowned with a success that they could never have foreseen.

Leaving the domain of electrical waves let us turn to another sensational discovery of seventeen years ago. We have seen that wireless telegraphy had been prepared for by the work of nearly three quarters of a century. In December, 1895, the world was startled by the announcement that Professor Röntgen, of Würzburg, had obtained from vacuum tubes in which an electric discharge was passing a new sort of rays, which, though invisible, would yet affect a photographic plate and also possessed the startling power of being able to pass through many

opaque substances, while casting shadows of others. Most wonderful seemed the statement that by these rays the bones of the hand could be seen. Seventeen years later these Röntgen rays are used in every hospital, and reveal the inmost secrets of the body. But this is not their interest to the physicist, but rather the fact that they have opened up a whole field of facts previously unsuspected, so that an investigator ignoring them would to-day be held the greatest of old fogies. How did Röntgen come to discover the X-rays? No doubt there was a certain element of chance. We are told that he had covered the discharge tube, the so-called Crookes tube, with black paper, so that no light should get out from it, and that Röntgen's attention was attracted by the fluorescence, or faint shining with light, of a piece of paper lying on the table, the paper being covered with the salt of barium platinocyanide. But why did this piece of paper coated with this uncommon chemical happen to be lying on the table, and why had Röntgen covered the Crookes tube with black paper? We find that barium platinocyanide was one of the substances that had been investigated by previous investigators as to its fluorescence, and that such paper was a commercial article in Germany. Röntgen must then have suspected that there was some property of the Crookes' tube that would cause fluorescence, so that the presence of this fluorescent paper was not accidental at all. This is then a striking example of what I have before stated. A further one is given by a discovery made the next year in Paris. Röntgen's discovery had set the world on fire, and had given rise to a renewed interest in the subject of fluorescence. Noteworthy among fluorescent substances are the salts of uranium, and these were examined by Henri Becquerel, the third generation of physicists of that name. Becquerel placed uranium salts against a photographic plate wrapped up in black paper, and soon found that the plate was affected, even through the opaque paper. At first Becquerel thought that the uranium had this property only after being exposed to the sun's light, but he soon found that the same properties were possessed by uranium salts that had been formed in the dark, and had never seen the sun. In short these salts are constantly emitting a new sort of radiation, now known as Becquerel rays. Physicists now began to look for other substances than uranium which had these properties, with the result that it was found that uranium-bearing ores were found to contain other substances having the properties in a far higher degree, and at last the Curies were able to separate a new element, which was named radium. The field of radioactivity thus opened up has become an enormous one, and many substances have been discovered having radioactive properties. Here is again an illustration of the impossibility of distinguishing between physics and chemistry, for although Mme. Curie is a chemist, the Nobel prize in chemistry was awarded a few years ago to Professor Rutherford, professor of *physics*

at the University of Manchester, England. Time will not permit me to go on with the history of this fascinating subject, but I will only remark that in all the great countries radiological institutes have been founded for the purpose of carrying on researches on the medical applications alone of radioactivity, so that here again we may expect great practical results.

I hope I have now sufficiently shown the nature of the contributions of the physical laboratory to civilization, not only in the practical matters of making life easier and more agreeable, but also in the extension of our intellectual outlook, and the making of life more worth living.

THE ORIGIN AND EVOLUTION OF THE NERVOUS SYSTEM

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TO the ancients what we designate as personality was a more or less general attribute of the human body rather than an aggregate of functions having a strictly nervous source. In fact Aristotle, who was such an accurate observer and profound thinker in so many fields of biology, denied positively that the brain was in any direct way concerned with sensation and declared the heart to be the sensorium commune for the whole body. To Galen is ascribed the belief that the brain was the seat of the rational soul, the heart the location of courage and fear, and the liver that of love. This distribution of the element of personality over the physical body finds its expression in the common speech of to-day, particularly in relation to the heart, which is widely accepted by the popular mind as the source of the more tender emotions. It was chiefly through the anatomists and physiologists of the early Renaissance that the modern movement, which has tended to limit personality to the nervous system, was seriously begun, a movement which, with the increase of knowledge, has gained support to such an extent that it can now be maintained beyond any reasonable doubt. Human personality is in no true sense the outcome of the non-nervous organs, such as the digestive or the circulatory organs, but is the direct product of the nervous system. This system, to be sure, is embedded among the other organs of the body and the environment thus provided influences profoundly its condition and action, but what is meant by individual personality, acuteness or dullness of sense, quickness or slowness of action, temperamental traits, such as a gloomy or bright disposition, incapacity, shiftlessness, honesty, thriftiness or sweetness, are all, strictly speaking, functions of the nervous organs. Although only the higher animals can be said to possess personality in this sense, traces of it occur in the lower forms and its evolution is indissolubly connected with that of the nervous system. It is the object of this paper to trace in broad outlines the development of those organs which in the higher animals come to be the seat of personality.

The nervous organs of the higher animals, including man, consist of enormously intricate systems of interwoven nerve cells or neurones whose unique character was first fully grasped some twenty years ago by Waldeyer. These neurones, like other cells, possess a nucleated cell-body, the ganglion cell of the older neurologists, from which extremely at-

tenuated processes, the nerve fibers, reach out to the most distant parts of the animal. These processes are the most characteristic parts of the neurone. Extending as they do in the largest animals for some meters from their cell bodies, they afford an example of a cell process such as is seen in no other histological unit. Not only are the nerve cells or neurones thus highly specialized in their structure, but they also exhibit profound physiological differentiation. Thus among the primary sensory neurones each one is connected, as a rule, with a particular portion of the animal for which no other neurone is responsible, and among the motor neurones each one controls a group of muscle fibers not called into action by any other neurone. Hence functional specialization among these elements has come to be so extreme that the nervous system may be described as one in which differentiation has reached to its very cells, a condition that is shown in no other elements of the body except possibly in the reproductive cells.

Notwithstanding the high degree of differentiation exhibited by the neurones of the higher animals, these elements may be easily grouped into relatively few classes distinguishable through their connections. These classes are three in number: first, the afferent, or as they are commonly called, the sensory neurones extending in general from the surface of the animal to the central organs and transmitting sensory impulses; secondly, the efferent neurones connecting the central organs with the muscles, glands, etc., and transmitting efferent impulses; and finally, what may be called the association neurones, to extend to the whole nervous system, a term used by Flechsig for elements in a limited part of the brain, or those neurones which lie entirely within the central organ and connect one part of this organ with another. Although the nervous organs of the higher animals are composed of an abundance of all three classes of neurones, the association neurones in all probability far outnumber those of the other two classes and constitute the chief mass of these organs.

Almost all nervous operations in the higher animals involve all three classes of neurones. The typical nervous reaction of these animals consists of a sensory stimulation followed by a motor response. This operation has been called a reflex, to use that term in its widest sense, that is, irrespective of the association of the action with voluntary or conscious operations. Such a reflex takes place over an arc of neurones, the sensory members transmitting to the association elements, and these in turn to the motor elements, but in describing the reflex its parts are not conveniently dealt with from the standpoint of the neurone. The reflex, as ordinarily understood, begins with the activity of a sense organ or receptor, from which a sensory impulse passes to the central nervous system or adjustor, whence the nervous disturbance makes its way to the third element or effector, usually a muscle. The sense

organs or receptors are, for the most part, the distal ends of sensory neurones. The central organs or adjustors include the proximal ends of these elements, all the association neurones, and the proximal ends of the efferent neurones. The effectors are not neurones at all, but muscle fibers, gland cells or other types of cells under the control of nerves. Thus the ordinary reflex may be said to involve in sequence the activity of a receptor, adjustor and an effector, to use modern terminology, and these three elements are recognizable in every complete reflex arc.

Our own reflexes are sometimes associated with consciousness and sometimes not. When we pass from a region of dim light to one of bright light the pupils of our eyes contract without our being conscious of the fact. In a similar way, when food is introduced into the digestive tract, a whole succession of reflex movements is called forth without any direct relation to our consciousness. On the other hand, if we burn a finger, it is usually withdrawn with full recognition of the sensation and the response. Thus a reflex may or may not be association with a conscious state.

From this standpoint, what is the condition in the lower animals? Have they nervous systems composed of neurones and exhibiting reflexes which in some instances are associated with consciousness, and in others not? In other words, what have been the steps by which has developed that mechanism which serves us at once as the means of our simplest reflexes and the material basis for our intellectual life?

As an example of the lower animals whose nervous activities are worthy of consideration we may take the earthworm. This animal has at its anterior end a small brain from which a ventral ganglionic chain extends posteriorly through the rest of its body. It possesses sensory neurones which extend from the skin into the central nervous organ and motor neurones reaching from the central organs to the muscles. The central organ itself contains association neurones. Thus the three classes of nervous cells which occur in man are also represented in the earthworm but with this difference. The association neurones, which in man are relatively very numerous, are in the earthworm comparatively few. Otherwise the essential composition of the nervous organs in these two forms has much in common.

Not only is the nervous system of the earthworm composed of elements essentially similar to those of the higher animals, but it exhibits similar functional relations. The earthworm responds to a large range of stimuli by appropriate and characteristic reactions, and its movements justify the conclusion that its reflex arcs, like those of the higher animals, involve receptors, an adjustor, and effectors.

Whether certain of the reflexes of the earthworm are associated with consciousness or not is a question that can not be answered definitely,

since no absolute criterion for consciousness in any organism other than one's self can be given. Earthworms, however, apparently possess some capacity to profit by experience. Within the past year Yerkes has reported on the training of an earthworm which in a surprisingly short time acquired the habit of escaping successfully from a very simple maze. These results, should they prove true for other individuals, suggest a certain degree of consciousness in these creatures as a basis of their ability to learn. It is, therefore, not impossible that certain of the reflexes of earthworms may be associated with conscious states, even though these states may be of a very low order.

But, though the reflexes of the lower animals show some features that suggest consciousness, it is not probable that this state is anything like as characteristic of these simple forms as of the more complex ones. Certainly some of the performances of these more primitive beings have every mark of the unconscious reflexes of our own bodies. Thus bees that have been artificially hatched and have never seen the colony at work make as perfect comb as though they had learned the art by having been co-workers in an established hive. Such bees, moreover, will not only build comb such as they themselves were hatched from, but will shape a queen cell, a form with which they have had absolutely not the least acquaintance in the past. Thus the very complex operation of comb-building in the bee resembles our own unconscious inborn reflexes, such as the constriction of the pupil and the movements of the digestive tube, rather than our voluntary operations, and this is probably true of many of the activities of the lower animals. In fact, it seems fair to conclude that, though such animals as the insects, crabs, and even the worms, possess a nervous system composed of elements similar to those in the higher forms, their reflexes are much more mechanical and less associated with anything that can be called a conscious state than are those of the higher forms. In other words, these lower animals are more in the nature of reflex machines than are the higher forms, though they are not, as some investigators would have us believe, exclusively so.

But if the nervous system in many of the lower animals is composed of elements similar to those in the higher forms, and exhibits activities not unlike our own, are there not still more primitive animals in which this system shows a real reduction and exhibits a condition which marks the actual beginnings of nervous organization? Such primitive forms have long been supposed to exist among the cœlenterates and are well represented by the sea-anemones.

Sea-anemones are sack-like animals with a single opening leading into the digestive cavity and serving both as mouth and anus. This opening is usually surrounded by a cluster of tentacles. The living body of the sea-anemone consists of the thin membranous wall that

separates the digestive cavity from the outer sea-water, and that is drawn out in processes to form the hollow tentacles. In no part of its structure is the sea-anemone massive, as is the case in most higher forms, where the muscles, skeleton and so forth usually give rise to a considerable thickness of tissue; in fact, the animal exhibits no well-defined organs except the digestive organs, and may be described as a membranous digestive sac.

Although the body of the sea-anemone is really nothing more than membranous walls, these walls have long been known to contain both nerve and muscle. These two tissues occur over almost the whole animal. According to the Hertwigs, the nervous tissue is more abundant in the neighborhood of the mouth than elsewhere, and this region has been regarded by some investigators as a central nervous organ. But the studies of Jordan and others have shown conclusively that this opinion is not correct, and that the removal of this region interferes in no serious way with the reactions of the animal. Apparently each part of the sea-anemone carries with it its own neuromuscular mechanism, a condition well illustrated by the tentacles. These organs are chiefly concerned with appropriating the food and are stimulated by the dissolved materials in the food. A tentacle when cut off from a sea-anemone and held in sea-water can still be stimulated by food and will exhibit almost exactly the same kind of movements when thus isolated that it did when a part of the whole animal, thus demonstrating the completeness and independence of its own neuromuscular mechanism. Nervous transmission can be accomplished from almost any part of the sea-anemone to almost any other part, but as such experiments as those with the tentacles indicate, no one part of the animal's nervous organization seems to be more important than any other part. In other words, the nervous system in the sea-anemone is diffuse rather than centralized.

When the minute organization of the nervous system of these animals is studied, it is found to consist of a vast number of sensory neurones which connect the surface of the animal with the underlying muscles and which form there what appears to be an intricate nervous network. This nervous mechanism is concerned primarily with the reception of stimuli and the immediate excitation of the muscles. The nervous mechanism is a receptor mechanism that acts as a trigger for setting off the muscle. The whole neuromuscular apparatus seems to be made up of those two elements which in the higher animals were designated receptors and effectors and without the intervention of an adjustor or central nervous organ. Viewed from the standpoint of development, this condition points indubitably to the conclusion that the central nervous organs were evolved only after the appearance of sense organs and muscle, and that such animals as the sea-anemone may well be taken

to represent this step in the evolution of the nervous system. This general view of the origin of the central nervous organs was advanced as early as 1886 by Kleinenberg and was reaffirmed ten years later by Rakowitza.

The evolution of nerve and muscle, so far as this problem can be attacked in such lowly form as the sea-anemone and other cœlenterates, is a question about which there has been much difference of opinion. As early as 1872 Kleinenberg showed that in the fresh-water cœlenterate, *Hydra,* there were certain peculiar T-shaped cells that he called neuromuscular cells and that he believed to represent both nerve and muscle. In these cells the arm of the T reached the surface of the animal and was thought by Kleinenberg to act as a nervous receptor; the cross-piece being contractile was known to be muscle. Kleinenberg assumed that the division of such cells and the differentiation of their parts were the processes which gave rise to the nervous and muscular tissues of the higher animal. In 1879 the Hertwigs in their account of the structure of sea-anemones showed that the so-called neuromuscular cells of Kleinenberg were in reality simply epithelio-muscle cells and were without nervous significance. These investigators, in opposition to Kleinenberg, advanced the view that nerve and muscle, though simultaneously differentiated, were derived from different groups of cells. According to both Kleinenberg and the Hertwigs nerve and muscle were simultaneously evolved, but Kleinenberg maintained that these tissues came from a single form of cell, the Hertwigs that they arose from separate kinds of cells.

My own studies on the origin of nerve and muscle have led to rather different conclusions from those summarized in the last paragraph. In studying the reactions of one of our common sponges, *Stylotella,* I was impressed with the extreme slowness with which the animal responded to a stimulus. The oscula of this sponge can be made to close by the application of several kinds of stimuli. The closure of these openings is accomplished by the contraction of the ring of muscular tissue surrounding them. This response occurs some minutes after the stimulus has been applied, a condition in strong contrast with the quick reactions of such animals as sea-anemones. These forms respond to most stimuli within a second or so, the sponges only within minutes. Moreover, in sponges transmission from the place where the stimulus is applied to the responding muscle is possible only over very short distances and is carried on at a very slow rate. Transmission in *Stylotella* resembles very closely the kind of transmission seen in ciliated epithelium. The successive beat of the cilia is dependent upon an impulse which progresses from cell to cell in the epithelium at a relatively slow rate and is neither purely mechanical nor nervous in its method of propagation. It probably represents a primitive form of

protoplasmic transmission, a forerunner of the true nervous impulse, and as such gives us some insight into the nature of the non-nervous transmission in sponges. The results of my studies on *Stylotella* support the conclusions of most biologists who have worked upon sponges, that these animals probably possess no true nervous tissue. Their muscles, in my opinion, are brought into action almost entirely by the direct effect of the stimulus rather than through nerves, and this accounts, I believe, for their very slow response to external disturbances. It is possible that in certain sponges some form of nervous tissue may be demonstrated eventually, or that such organs as those described by von Lendenfeldt as synocils may be shown to have a sensory significance, but such cases, if they do occur, will probably remain exceptional, for as a whole sponges seem to be a group of animals almost if not quite devoid of true nervous tissue. Granting this conclusion, it must be evident that the condition in sponges throws a very important light on the question of the origin of nerve and muscle. Their state suggests at once that nerve and muscle have not been differentiated simultaneously, as maintained by Kleinenberg, the Hertwigs, and others, but that muscle preceded nerve in its evolution and that sponges represent animals with effectors but without differentiated receptors. If then it may be claimed that phylogenetically the sense organ preceded the central nervous organ, it may also be maintained that muscles preceded sense organs. Thus the three elements of the reflex arc of the higher animals were probably evolved separately and in the order, effector, receptor, adjustor.

If muscle originated before nerve and was brought into action at first by direct stimulation, it is natural to expect that examples of this form of response might still be found among the higher animals. And such seems to be the case. Thus the sphincter of the iris in the lower vertebrates, though well known to be under the influence of nerves, was shown by Steinach some time ago to be directly stimulated by light, a condition which, judging from the more recent work of Hertel, probably applies even to the human eye. This muscle then exhibits a certain capacity for normal direct stimulation. Another example of the same kind is seen in the embryonic vertebrate heart. Though the beat of the adult heart may be a matter of controversy from the standpoint of the myogenic and neurogenic theories, there can be no doubt that the muscle of the embryonic heart beats, as shown by His, before it has become invaded by nerves. And this view is supported by Barrow's recent discovery that the isolated cells of the heart-muscle will contract rhythmically under conditions where not the least vestige of a nerve can influence them. Thus the embryonic heart-muscle and the sphincter of the iris are muscles whose activity may be normally called forth by direct stimulation, a condition which reproduces, so far as independence is con-

cerned, the state met with in the muscles of the sponges. These examples then show that even in the higher animals certain muscles respond normally to direct stimulation and thus exhibit a form of activity which is believed to be generally characteristic of sponges.

In my opinion the simultaneous origin of nerve and muscle can no longer be maintained. Muscle arose first and the simple effectors thus produced were the first element of the neuromuscular mechanism. These effectors were directly stimulated and consequently slow in action. They afforded centers around which nervous tissue first differentiated in the form of sense organs or receptors whose function it was to serve as triggers to initiate muscle action quickly. As these receptors became more highly developed, a third element, the central nervous organ, arose from the nervous elements between the receptor and the effector. This organ, the adjustor, served as a means of conducting and modifying the sensory impulses on their way from the receptor to the effector and ultimately it also served as a storehouse for the nervous experience of the individual and as the seat of its intellectual life. It is interesting to observe that this view of the origin of the nervous system is in accord with the philosophical speculations of Bergson according to whom the nervous system has been evolved primarily as an organ for animal response and only secondarily as one concerned with intellectual activities.

But if we picture the nervous system as having arisen as an appendage to the musculature and as having grown in complication as the musculature became differentiated, we are still far from an adequate view of even the more obvious aspects of its evolution. The nervous system controls many more kinds of effectors than muscle and its sensory elements are vastly more complex than is implied in the preceding sketch. To gain a more comprehensive view of the evolution of these organs, it is necessary to consider a subsidiary but important process, the appropriation of effectors and receptors.

The nervous system of many of the higher animals not only acts upon the musculature; it may also control electric organs, luminous organs, chromatophores, glands, etc. Not all such organs are under the influence of the nervous system, but it is not difficult to find for each group of effectors animals in which the given type of organs is under the influence of nerves. The electric organs and the chromatophores of fishes, are of this kind as well as the salivary glands of the mammals and the luminous organs of the brittle stars.

How has the nervous system gained control over these organs? Except the electric organs, which are probably modified muscle, all these organs have arisen in my opinion as independent effectors. Most of them can be identified as such in one group of animals or another. Thus among the glands the pancreas in the higher vertebrates has been

shown to be in its action essentially non-nervous. Such highly differentiated, but independent effectors have, I believe, been appropriated from time to time by the nervous system in that during ontogeny certain motor fibers, instead of becoming attached to their appropriate muscles, have wandered to new effectors which have been sufficiently responsive to their stimuli to give a basis for a permanent attachment. Thus the nervous system, once established around muscles, has widened its influence in that it has appropriated other types of independent effectors, which upon application were found to be responsive to its stimulus.

But the differentiated nervous system has not only extended itself on the side of its effectors, it has probably also made receptor appropriations. This is well illustrated by several groups of related sense organs such as the organs of touch and hearing in the vertebrates or those of the chemical senses in the same animals. The latter may serve as an example.

The chemical sense organs in vertebrates include not only those of smell and of taste, but also the organs of the common chemical sense such as are concerned with the chemical irritability of the skin of the frog or of the exposed or semi-exposed mucous surfaces of man. All these chemical receptors are stimulated by solutions. In taste the stimuli are the dissolved materials in the food; in smell they are the solutions formed on the moist olfactory surface from the materials wafted in the air to the nose.

The neurones concerned with the reception of these stimuli exhibit interesting relations. The olfactory neurones, as is well known, have their cell bodies in the olfactory epithelium, whence their neurites extend into the central olfactory apparatus. They reproduce in a most striking way the type of primary sensory neurone common to the invertebrates, and in this respect they represent the most primitive type of sensory neurone in the body of vertebrates. The neurones concerned with the common chemical sense are like those of the olfactory sense except that their cell bodies have migrated centrally and constitute a part of one of the cerebro-spinal ganglia. As a result the distal ends of these neurones are represented as free-nerve terminations in the epithelium of the moist parts of the vertebrate skin. The gustatory neurones reproduce almost exactly the condition of those of the common chemical sense, except that their distal free terminations are around taste buds instead of being in an ordinary epithelium.

The conditions shown by these three types of receptor mechanisms suggest at once a genetic connection. The olfactory type is undoubtedly the most primitive, and stimulation in this instance is initiated by the chemical action of the superimposed solution on the hairs of the olfactory cells. The neurone for the common chemical sense has prob-

ably been derived from one of the olfactory type by a proximal migration of its cell body. The stimulation of its free-nerve terminals may be conceived to take place, as Botezat has recently pointed out, through the secretory activity of the surrounding epithelial cells as a result of their contact with the stimulating solution, rather than from the direct action of this solution on the nerve endings themselves. From this standpoint the epithelium comes to be an essential element in the stimulation of the neurone and affords, so to speak, a favorable sensory environment for the real nerve-endings. Finally, the gustatory neurones may be said to have appropriated certain of these epithelial cells which have become differentiated into taste buds and whose activity, probably secretory in character, to follow Botezat, is called forth by the superimposed solution and is essential to the stimulation of the nerve endings.

Thus in the evolution of the chemical sense organs of vertebrates certain integumentary cells originally quite independent of the receptors came to be involved with these and were eventually appropriated by them as essential parts of the gustatory apparatus. This process of appropriation is not unlike that seen among the effectors and represents one of the important steps by which the nervous system in the course of its evolution has added to its complexity. Although the nervous system probably arose in a scattered way at spots where the primitive multicellular animal had developed muscle, it became unified through the need for general transmission tracts, and, by increasing its own elements as well as by appropriating additional effectors and receptors, it has impressed upon the higher animals, including ourselves, a unity so profound that it includes everything that we mean by personality.

CURRENT PROGRESS IN THE STUDY OF NATURAL SELECTION

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I. Introductory Remarks

IN papers on "The Measurement of Natural Selection" and "On Assortative Mating in Man," which have appeared in these pages,[1] I have endeavored to show by a review of the quantitative work already done that natural selection and sexual selection are not subjects for idle speculation and polemics, or even for inductions from comparative evidence, but that, like the other factors of organic evolution, they are open to direct quantitative investigation.

It is perhaps not too soon to list up for the convenience of those who desire to take a broad view of evolutionary research, the studies in natural selection which have appeared since the first of these papers was written.

In doing this the ideals of the earlier papers will be carefully maintained. That is, only questions of observed facts and the methods of analyzing them will be taken into account. Theories will be ignored. Again, both positive and negative results will be given impartially, for in the real advancement of science both are of importance in the direction of research and in the formulation of laws.

It will be conducive to clearness to recognize that two fairly distinct problems confront the student of natural selection. The first is to determine whether in any given case the death rate is random or selective. The second is to ascertain what physical, physiological or psychological characteristics make for fitness or unfitness for survival. The attack upon the second problem presupposes the successful solution of the first, for if there be no evidence of the selective nature of the death rate, it is obviously idle to test the selective value of individual characteristics. It is equally clear that any study which stops short of the second of these tasks is in a high degree unsatisfactory. From the standpoint of evolutionary science it is desirable that the significance for survival in various environments of each type of variation in structure or function should be worked out. But this is a task of the highest difficulty and will probably never be accomplished for more than a few selected cases. In these exceedingly difficult fields practicability must be a primary consideration. In many cases, it may

[1] Pop. Sci. Mo., 78: 521–528, 1911; *loc. cit.*, 80: 476–492, 1912.

be quite out of the question to do more than determine whether the death rate is selective or random, and in such cases these first steps may be of very high importance indeed. Again, it may be feasible to plunge at once into the second problem by testing the value of character after character in the battle for life. In this case both phases are simultaneously taken up. These points will be made clear by illustrations.

II. Further Attempts to Ascertain whether the Death Rate is Selective and to Determine the Intensity of Selection

The first problem to be taken up is therefore that of the existence or non-existence of selective mortality. In a considerable range of living forms it is desirable to know whether natural selection is operative, even though it is for the time being out of the question to say how it is operative, *i. e.*, what particular characteristics make for incapacity or for fitness.

A. *The Simple Demonstration of the Existence of a Selective Mortality*

Studies on Plants.—A first illustration of the importance of the simple determination of the selective or non-selective nature of the death rate is to be seen in the cases of the northward extension of cereals or other cultivated plants. At present, very little is definitely known concerning the factors actually involved. It has been frequently assumed that natural selection through the agency of cold or of the shortness of the growing season has been one of these. This view seems to be supported by Waldron's[2] work on alfalfa. He shows that some strains are more resistant to cold than others, and that in the north the less resistant are eliminated. This is all that is necessary to bring about adaptation—which already exists in some strains.

Another most interesting piece of work differing widely in material and detail, but depending upon the same kind of reasoning, is that of Montgomery.[3] Our common cereals have been cultivated for hundreds or thousands of years with practically no attention to selection or grading until recent times. He suggests that under the system of planting two or three times as many seeds as can possibly come to maturity, a slow development has taken place through a continuous natural selection with the survival of the strongest.

He has several interesting results for competition, but his most conclusive experiments for selection are those with maize.[4] Planting

[2] L. R. Waldron, "Hardiness in Successive Alfalfa Generations," *Amer. Nat.*, 46: 463–469, 1912.

[3] E. G. Montgomery, "Competition in Cereals," *Bull. Neb. Agr. Exp. Sta.*, 127, 1912.

[4] E. G. Montgomery, *loc. cit.* Also "Thick and Thin Planting for Growing Seed Corn," *Bull. Neb. Agr. Exp. Sta.*, 112: 28–30, 1909.

continuously at the rate of one, three and five seeds per hill[5] for six years, he finds the yields given in the accompanying diagram, 1. Apparently the seed grown under competition yields higher than that grown under thin planting.[6]

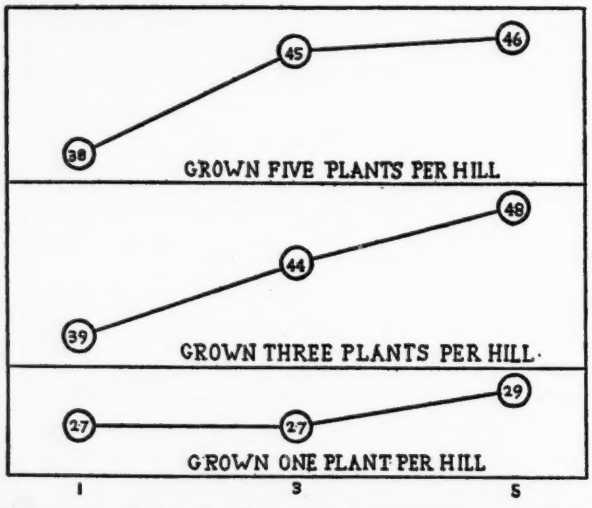


DIAGRAM 1. YIELD OF MAIZE FROM VARIOUS TYPES OF SEED.

The Selective Death Rate in Man.—Beyond all doubt the most important work on the question of the existence of a selective death rate has been done on man. This is true not merely from the standpoint of the critical nature of the investigations and the soundness of the conclusions, but from the sociological importance of the findings as well.

The pioneer work of Pearson and Beeton[7] already mentioned in these pages has recently been supplemented by the studies of Ploetz.[8] However conclusive these studies may be, it is most important to have light on this question from another angle. Precisely the information needed should be obtainable in the following manner.

If natural selection be a reality, then (other factors being rendered

[5] When planted at the rate of one per hill about 25 good ears weighing 12 ounces or more are produced to every 100 plants. With 3 plants per hill there are only about 10 good ears, with 5 plants, only about five. A plant capable of producing a good ear with four others in the same hill must be unusually vigorous, but in thin planting it is not possible to tell which of the plants would have been capable of reaching the high standard under keen competition.

[6] The details given in Montgomery's paper are entirely too meager for a problem of such great complexity.

[7] POP. SCI. MO., 78: 533–534, 1911.

[8] A. Ploetz, "Lebensdaur der Eltern und Kindersterblichkeit. Ein Beitrag zum Studien der Konstitutionsvererbung und der natürlichen Auslese unter den Menschen," *Arch. Rass.- u. Gesellschaftsbiol.*, 6: 33–43, 1909.

constant) the survivors of an infantile population subjected to environmental conditions making for a high death rate should in later years show a lower mortality than the survivors of a population subjected to less stringent conditions of life.

The Possible Selective Element in Infant Mortality.—That the preservation of the weaker children may result in a population of adults below the maximum physical fitness is an idea as old as the study of Spartan history. The wide acceptance of the Darwinian theory and the modern reduction in the death rate—accomplished largely by the saving in the early months of life—have combined to give it considerable prominence in recent years.

To solve the problem one must find a series of districts[9] differing as much as possible in the mortality of the early months of life, and determine whether those which have a lower mortality in infancy have a higher proportion of men unfit for military service or a higher adult mortality.

Such attempts have been made, for instance, by Rahts, Kruse, Gruber, Koeppe, Prinzing, Elben and others. The indeterminateness of these studies is apparent not only from the discordant conclusions but also from the obvious inadequacy of the statistical technique.[10]

To Yule[11] and Snow[12] belongs the credit of having first applied the modern statistics to this problem. Yule's data and methods, however valuable they may be from the standpoint of the relationships between the mortality of early and later life in a series of districts, seem quite inadequate to the solution of the problem of the selective or non-selective nature of infantile mortality.[13]

A first great merit of Snow's laborious study is that he fully recognizes the multiplicity of disturbing factors and has attempted in as

[9] Snow (see below) is quite right in insisting that the question as to what proportion of the general death rate is selective should be answered on national mortality statistics. From the point of view of evolution, or of sociology, such data are of far more value than the more complete records which can be secured in individual pedigrees, for to be of evolutionary or of national social importance the intensity of the selective death rate must be measured on a perfectly general population.

[10] Examples are given in subsequent footnotes.

[11] G. U. Yule, "On the Possible Selective Influence of Mortality in Infancy on Mortality in the Next Four Years of Life," Supplement to the Report of the Medical Officer of the Local Government Board (Great Britain), 1910, Cd. 5,263.

[12] E. C. Snow, "The Intensity of Natural Selection in Man," Drapers' Co. Res. Mem. (Univ. Coll., Lond.), Stud. Nat. Det. 7, p. 43, London, Dulan & Co., 1911.

[13] This is clear from the criticisms brought forward by Snow. Practically as much has been admitted elsewhere; see *Jour. Roy. Stat. Soc.*, 75: 133–135. In his study Yule shows a caution in interpretation of results which is not as evident in the main body of the medical officer's report.

far as possible to correct for them. His method may be described as follows:

The mortality of children born in any year, say 1903, in as large a series of districts as possible[14] is followed year by year. Working with this series which is *homogeneous with respect to year of birth*,[15] the problem to determine whether, allowing for environmental influence, the death rate of, *e. g.*, the first year, or of the first two years, has any influence upon that of subsequent periods of life.

Now this factor, which for convenience we have designated as environmental,[16] is of great importance. The death rate differs widely from district to district, and in response to many factors.[17] Thus *absolutely* districts having a low mortality for the first year of life might have a low mortality for the second to the fifth years of life; districts having a high death rate for the first twelve months of life would also have a high death rate for the thirteenth to the sixtieth month of life, since many of the causes operating in the two cases (bringing about high or low death rates) affect both age periods.

Thus a high mortality of infancy does not necessarily imply a low mortality of childhood or a high military efficiency. This is true because any influence of selection is largely obscured by such factors as ethnic or social composition or physical environment in the various districts. Before one can say anything at all concerning the possible

[14] It is very important that the subdivisions be as numerous and as homogeneous within themselves as is consistent with data for trustworthy death rates. For, obviously, the death rate in one district in a given year may be abnormally high (or low) because of purely local and transitory conditions. These are precisely the factors which make for a high or low selective death rate. By lumping a number of districts together one may cancel out the very terms he is seeking to investigate! The value of some of the published work is nullified by the neglect of this point.

[15] Obvious as the importance of this point is, it has been entirely overlooked or disregarded by some. To determine that the death rate of children 0 to 1 year of age and that of those 1 to 5 years of age in a series of districts are correlated for a given year, say 1905, proves nothing at all concerning a selective death rate. The infants exposed to conditions (in the various districts) resulting in high and low death rates for their first year of life in 1905 are being compared with those exposed to the action of selection under what may have been widely different conditions in 1904, 1903, 1902 and 1901. The whole factor of the variation in mortality from year to year due to epidemics, meteorological conditions, economic changes, etc., is thus left entirely out of account.

[16] Local influence might have been a better term, since racial composition as well as environment may play a part.

[17] The fact that the death rate is to so great extent within the control of the sanitary and charity boards is sufficient general evidence for this statement. A quantitative demonstration is seen in the fact that a correlation is found between, *e. g.*, the birth rate and infantile mortality; also between artificial feeding rate and infantile mortality. See Greenwood and Bevan, *Jour. Hyg.*, 12: 5–45, 1912.

selective nature of the death rate at the beginning of life he must make due allowances for these factors.

Snow attempts to correct for this environmental factor by using the deaths other than those for the infants born in the particular year under consideration as a measure of the stringency of its influence. The precise manner in which this is done need not concern us here, nor is it necessary to explain in detail the various ways in which the mortality of the first years of life was split up into earlier and later periods in order to ascertain what influence, if any, excessive mortality in the earlier period has upon the chances of survival in the later. Indeed, to discuss adequately all of the difficulties encountered and the highly complex methods by which they were largely overcome by Mr. Snow would treble the space which may be devoted to his research, and transform a review intended for the layman into a discussion comprehensible only to the trained statistician.

For present purposes, it is sufficient to say that (correction being made for environment), those districts in which the mortality for the first period was high had in general a low mortality in the second period.[18] Thus in the long run a high mortality in childhood follows a low mortality in infancy; low mortality in childhood follows high mortality in infancy—remembering always the correction for environmental factors which may hide the action of selection.

Natural selection, in the form of a selective death rate, is strongly operative in man in the early years of life.[19]

M. Greenwood and J. W. Bevan, "An Examination of Some Factors Influencing the Rate of Infant Mortality," *Jour. Hyg.*, 12: 5–45, 1912, find some evidence of the selective nature of infantile mortality in the Bavarian data of

[18] All of Snow's results are not concordant. There are good reasons for believing that some of the series of public statistics analyzed by him are inadequate for so complex and delicate a biological problem as that of selective mortality. Those series of data which biologically and statistically may be regarded as most suitable and trustworthy evidence the most strongly in favor of the selective nature of infantile mortality.

One's confidence in Snow's own interpretation of his results is strengthened by the fact that he has laid all his evidence—that which goes against his own general conclusions as well as that which supports his view—before his reader, believing it to be "more in accord with scientific spirit that the reader should be allowed to draw his own conclusions from the whole of the research, and to form his own opinion on the value of the material used and of the results deduced from it." It is a great pity that such merit should be so distinctive as to require comment, but to-day there is a most unfortunate tendency, among biologists at least, to pigeonhole the *contra* and publish the *pro*. Thus current and popular theories are often for a time bolstered up, when if all of the facts were brought forward their standing would be much less secure.

[19] The reader who goes thoroughly into these problems will read an editorial criticism of Snow's paper in *Jour. Roy. Stat. Soc.*, 75: 133–135, 1911; also the reply by Snow in *Biometrika*, 8: 456–460, 1912, where the criticisms seem to be fully met.

Groth and Martin, but they justly emphasize the great difficulty of the task and the need of wider and better statistics.

B. The Selective Value of Particular Characters

Whenever possible students of natural selection have plunged at once into the problem of the way in which elimination takes place. When only the normal mortality is found for individuals with a given character, or intensely of the given character, selection is there inoperative; when a higher mortality is demonstrated, selection is tending to weed it out; when a lower mortality exists, natural selection is allowing it to gain ground in the struggle for existence. In the following paragraphs the results secured in this field are set forth.

Seed Weight and Mortality.—Among flowering plants, the highest death rate occurs in the seedling stage, just as among animals the force of natural selection is well nigh spent by the time a given generation reaches maturity.

It seems most important, therefore, to inquire what influence, if any, the characteristics of the seed or of the plant from which it was harvested have upon its viability. Closely correlated with, but quite distinct from, this problem is that of ascertaining what weight the morphological or physiological characteristics of the young seedling has in determining its chances of survival. It is only recently that these promising fields have been entered.

Consider first the visible characteristics of the seed itself. Montgomery[20] in addition to his studies on competition in cereals, has investigated the survival of plants from small or undeveloped as compared with that of large plump seeds of wheat and oats when planted in competition.[21] He finds that when each kind is planted alone a slightly higher percentage of plants is harvested from the large, well-developed seeds. Thus there is a considerable difference in the original quality of the seed. When planted in (inter-varietal) competition there is apparently a still further advantage in the large seeds. But it appears to be very slight indeed.

It seems that there are almost as many weaklings susceptible to the effect of competition among the plants from large seed as among those from small seed.

As far as I am aware[22] the only comparable studies have been made on garden beans.[23]

[20] E. G. Montgomery, "Competition in Cereals," *Bull. Neb. Agr. Exp. Sta.*, 127, 1912.

[21] Unfortunately, an intra-varietal competition test for seeds of the two kinds could not be made. The large and small seeds were alternated in the row. To distinguish the two at harvest time it was necessary for them to be of different varieties. Inter-varietal competition probably introduces some factors not present when all the individuals are of the same strain.

[22] The literature of seed testing is very large and much attention has been given to the produce of large and small seeds. Practically all the work has been

In these experiments the seeds were all carefully examined to make sure that they were perfectly developed[24] and differed only in size.[25] The biometric constants of 28 series which developed into mature plants have been compared with those for the original series of seeds from which the plantings were drawn.[26]

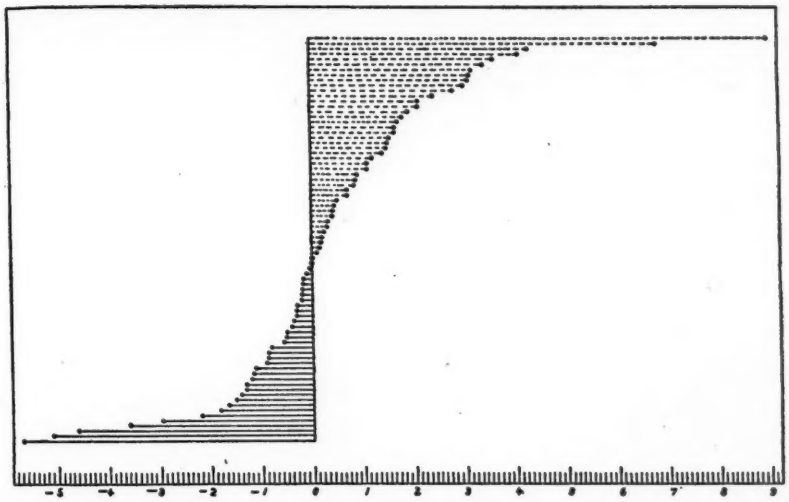


DIAGRAM 2. DIFFERENCES IN MEAN WEIGHT OF GENERAL POPULATION OF SEEDS AND OF THOSE WHICH PRODUCE PLANTS. All differences are reduced to a percentage basis.

The results of these studies can be most conveniently presented graphically. To demonstrate more clearly to the eye the existence of a

done on too small a scale to be conclusive. Possibly among these writings some records of the viability of seeds of different sizes may be found.

[23] J. Arthur Harris, "On Differential Mortality with Respect to Seed Weight Occurring in Field Cultures of *Phaseolus vulgaris*," *Amer. Nat.*, 46: 212–225, 1912.

[24] Unfortunately many students of seed weight in its relation to viability or productiveness have not distinguished between small but perfectly developed seeds and those which are blighted or shriveled and immature. It is not at all unlikely that very different results will be secured from the two sorts.

[25] Weighings were made of each seed in units of .025 grams, that is, 0.000–0.025 grams = 1 unit, 0.025–0.050 = 2 units, etc.

[26] Since the seeds were taken quite at random any stringent selective mortality will be seen in the differences between the constants of the original bulk of seeds weighed and those of the sub-samples planted which actually developed to maturity. The method might not be adequate for a very low selective death rate. In any case it must be expected to give irregular results. A much more satisfactory method is to draw the comparisons between the constants of the seeds which died and the constants of those which developed. Appropriate data for field culture series are being collected. Large greenhouse cultures in sand in which the comparisons can be made between the seeds actually developing and those failing to develop fully substantiate the conclusions drawn from field tests.

differential mortality with respect to seed weight, I have combined in Diagrams 2–3 the data from the field trials already published with those from a series of experiments on germination in sand. The lumping of the two sets of experiments which differ in some slight but apparently significant details to give sufficient series to make smooth graphs is justified by the fact that individually they lead to essentially the same conclusions and that the data and minute comparisons are to be presented in full detail eventually.[27]

Diagram 2 shows the relative differences in type (mean seed weight)[28] between the total samples of seeds weighed and those which produced plants.[29]

Here the heavy vertical bar represents zero difference between the average weight of the total population of seeds and those which actually produce plants. The broken lines and circles to the right show on the scale at the bottom, where each unit represents one tenth per cent. the number and amount of the positive differences, that is to say of those in which the seeds which survived are heavier. The heavy lines and solid dots to the left of the zero bar indicate the number of experiments giving negative differences—*i. e.*, in which the mean weight of the series of seeds which produced plants was less than that of the general population—and the amount of the difference in relative weight.

Judging the areas of light and dark shading, by the eye alone, one would conclude that the surviving seeds are slightly heavier than the population from which they were drawn. But the deviation from the equality of division which would be expected if there were no relationship between the weight of the seed and its capacity for survival is only 4 ± 2.98 cases, and little significance can be attached to it. For the

[27] J. Arthur Harris, "Supplementary Studies of the Differential Mortality with Respect to Seed Weight in the Germination of Garden Beans." To be published shortly.

[28] Several varieties of beans grown under diverse cultural conditions are involved. The varieties with the largest seeds are about three times as heavy as the smallest. To express the differences in absolute weights has its advantages, but when the number of series involved is too large for individual labeling in the graph, it is best to reduce values to a relative (percentage) basis by multiplying the difference by 100 and dividing by the mean for the general population.

[29] Here lies one of the objections to combining the two series of experiments. In the field culture the eliminated seeds were those which failed to produce fertile plants. In the sand cultures the fate of a seed could be followed only to germination. Some of the seedlings were abnormal, but to avoid all possibility of criticism every seed which germinated at all was included in the viable class. Doubtless in field cultures some of these would have perished before producing seeds. By retaining all these we are possibly making out a poorer case for differential mortality than we might by considering a part of the abnormal seedlings incapable of survival to maturity under field conditions.

whole 78 series the mean difference is less than five tenths of one per cent.[30]

Thus if we confine our attention to the mean, there is apparently no selective elimination whatever, for within the limits of experimental error there is no certain change in the mean value of the character considered. But an entirely new and different light is thrown upon the whole question when the variabilities are examined. These are distinctly less on the average for the series which develop to maturity.

This is brought out with great clearness by Diagram 3.

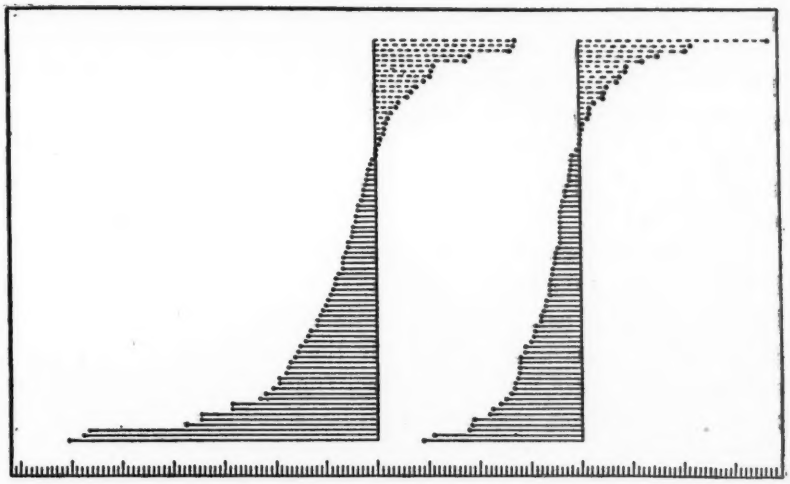


DIAGRAM 3. DIFFERENCES IN VARIABILITIES OF GENERAL POPULATION OF SEEDS AND OF THOSE WHICH PRODUCED PLANTS. The figure to the left shows the ratio of differences in standard deviation to their probable errors (1 space on scale = .2). The figure to the right shows differences in coefficients of variation (1 space on scale = .11 per cent.). The vertical lines give the points of zero difference.

In general form these figures are similar to the one representing the means, but an additional point is brought out by the one for the standard deviations, to the left. In this case the length of the bars indicates not absolute nor relative values of the variabilities, but the trustworthiness of the constants. Here the base scale is in terms of the ratio

$$\frac{\text{Difference}}{\text{Probable Error of Difference}},$$

each unit being equivalent to .20.

Instead of the light and dark line areas being approximately equal they are widely different. In only 22 cases is the variability of the

[30] The mean difference in weight is more nearly zero in the 28 field experiments than in the 50 made in the greenhouse. There may be valid biological reasons for this, but they can not be discussed here.

series of seeds which survive greater than that of the original distribution, while in 56 cases it is less. This is a deviation from equality of 17 ± 2.98, or over five times its probable error. One might have to toss coins a long time to get 22 heads and 56 tails in a series of 78 throws!

Furthermore, the individual constants indicating a lowering of variability by selection are statistically much more trustworthy than those suggesting a decrease. To carry much weight a difference between two constants should be at least two and one half times its probable error. But only 5 of the broken lines reach a straight edge laid 2.5 above (to the right of) the zero bar, while 22 extend beyond the same limit on the other side.

The coefficients of variation are already in relative terms—variability expressed in percentages of the mean—hence they may be represented directly by the direction and length of the lines in the figure to the right. For this graph, one unit on the base scale means one tenth of one per cent. The results amply confirm those secured by the preceding method.

These graphs are deduced from experiments involving tens of thousands of individually weighed seeds. Their evidence for a selective mortality can not, therefore, be lightly set aside. That the average weight remains unchanged while the variability is decreased can only mean that there is an elimination from both the upper and lower extremes of variation, that is, of both large and small seeds.[31]

Nevertheless, too great caution can not be used in the interpretation of the result. Purposely, the materials selected for study were most varied, and while the validity of the general *average* result can not be seriously questioned, there remains the problem of determining whether, and if so to what extent, the selective mortality may not fluctuate widely with different varieties and conditions.

The whole problem of the underlying physical and chemical causes of the differential mortality remains to be investigated. Finally, the possible relationship of the selective mortality to organic evolution can not be discussed until we have further evidences along several different lines.

Potential Characteristics and Seed Mortality.—When we turn to the question of the possible influence of the characteristics of the adult plant innate but invisible in the seed upon the chances of survival, the data are very scarce indeed.

Montgomery's studies of the rise in productiveness in corn as a result of increased competition may perhaps be of interest here. The

[31] Montgomery, *supra*, found little difference in the capacity of large and small seeds for producing mature plants in the cereals. Had he worked with the whole range in size and taken into account variability as well as type he might have found stronger evidence for selective mortality than he did.

most important case is undoubtedly that of single and double stocks. Double stocks are completely sterile, forming neither ovules nor pollen. They must, therefore, be propagated exclusively by seeds from singles. In the effort to place on the market seed which will produce the highest possible proportion of doubles, the closest attention has been given to all factors—shape and color of seed, position of the seed in the pod, position of the pod on the plant, etc.

At the beginning of the last century, the belief was current[32] that a larger proportion of doubles can be obtained from old than from recently harvested seed. Apparently, the original idea was that the transformation took place in the harvested seed, but Goebel suggested that its foundation may lie in a differential viability, the seeds which would have produced singles losing more and more their power of germination as time goes on.

Saunders[33] seems to have put the empirical conclusion and Goebel's interpretation on a scientific basis. In actual experiments which need not be detailed, she found that as the percentage of germination decreased by keeping the seeds for long periods of time, the proportion of doubles increased. She also found that when, through unfavorable conditions, the seeds were of a poor quality and a high percentage failed to germinate, the proportion of doubles was greater. Thus if the pods of 1909 be classified in two groups according to whether they produced less than fifty per cent. or fifty per cent. or more seedlings, we find for two strains:

	Percentage Doubles in:	
Variety	Low Germination	High Germination
Marine blue	72.0	51.5
Light purple	59.5	52.5

While Miss Saunder's results seem fairly conclusive the difficulties of the problem are, as she points out, considerable. A careful experimental investigation on a large scale of the viability of the seed in double stocks and in other ever-sporting varieties would be of the greatest interest.[34]

Seedling Characters and Survival.—Having shown that the measurable characteristics of the apparently normal seed, or the invisible potentialities of its embryo, may be of importance in determining its viability, *i. e.*, that they may be of "selective value," one next inquires whether in the young plantlet some variations tend to be weeded out.

We are indebted to Baur for a neat demonstration.[35] That plants

[32] See Goebel, Pringheim's *Jahrb. Wiss. Bot.*, 17: 285, 1886, for references.

[33] E. R. Saunders, "Further Studies on the Inheritance of Doubleness and Other Characters in Stocks," Appendix I., *Journ. Gen.*, 1: 361–367, 1911.

[34] Experimental work along the lines suggested by de Vries's discussion, "Species and Varieties," 2d ed., pp. 329–339, would be most important.

[35] E. Baur, "Untersuchungen über die Erblichkeitsverhältniss einer nur in Bastardform lebensfähigen Sippe von *Antirrhinum majus*," *Ber. Deutch. Bot.*

with inadequate photosynthetic apparatus would be incapable of survival seems on *a priori* grounds quite probable.[36] He found that in the snap dragon, *Antirrhinum majus*, a variegated or "aurea" form could not be bred true, but on self fertilization gave a progeny of "aurea" and green plants. The inbred green plants produced only green offspring, while the variegated individuals again gave two types of offspring in the ratio of two variegated to one green.

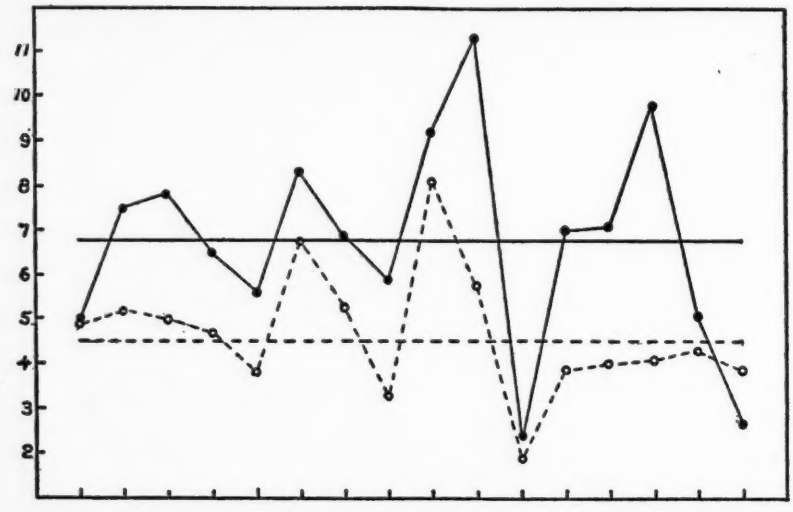


DIAGRAM 4. MORTALITY IN SIXTEEN LOTS OF TYPICAL AND ATYPICAL BEAN SEEDLINGS.

Evidence which need not be detailed here pointed to the conclusion that the variegated was the hybrid form, segregating on self-fertilization according to the simple Mendelian formula into one fourth green, one half variegated (heterozygous) and one fourth lacking chlorophyll —and consequently unfit for survival. Subsequent studies proved that the seeds incapable of forming chlorophyll are actually formed, but that they die in the early stages of germination, or before. Confirmatory results were obtained with a geranium, *Pelargonum zonale* "verona" where the seedlings lacking chlorophyll died at an early stage.

The preliminary results of a series of investigations on the struc-

Ges., 25: 442–454, 1907. Also, "Die Aurea-Sippe von *Antirrhinum majus*," *Zeitschr. f. Ind. Abst. u. Vererbungsl.*, 1: 124–125, 1909. Cf. also Bateson, "Mend. Princip. Her.," p. 253, 1909.

[36] De Vries ("The Mutation Theory," I., 229–230, 347–353, 1909; "Species and Varieties," 2d ed., pp. 537–538, 553) finds that *albida* mutants of *Œnothera* are very weak—exceedingly difficult to raise when appearing in the seed pan, and never found in nature.

Among large numbers of bean seedlings which I have grown in the greenhouse those with white, yellow or variegated primordial leaves have occasionally appeared. It has never been possible to grow these for any considerable time.

tural characteristics of seedlings in their relation to survival are at hand for garden beans, *Phaseolus vulgaris*.[37] From a lot of about 238,000 seedlings germinated in the greenhouse in sand, somewhat over 9,000 abnormal and normal plantlets were transferred to the field under as nearly as possible identical conditions. The diagram shows most clearly that the death rate, though very low, is unquestionably selective. Solid dots and lines represent the mortality of the atypical individuals in sixteen arbitrary but logical classes.[38] The actual numbers of deaths in these classes is not large. The death rates consequently fluctuate widely. Yet in every case but one the mortality of the atypical is higher than that of the typical individuals. The solid bar gives the rate for all atypical seedlings while the broken line smoothes the circles connected by broken lines in the same way.

Seedlings are thrown only into two classes, typical and atypical. The latter is highly heterogeneous, comprising a very wide range of structural variations. Possibly some of these are more fit for survival than are the normal individuals, while others are far less so. Only the collection of far wider series of data will settle the question. On an average the variations from type are clearly inferior. This is precisely the condition which one would expect if natural selection has been a factor of weight in the development of the structural characteristics of the seedling, for the most fit type would be the one preserved.

It is important to remember that this selective mortality is found in seedlings germinated under as favorable conditions of substratum and temperature as we could give them, and then transplanted to fairly good garden conditions. In nature, a considerable part of the seedling death rate doubtless occurs in the early stages of germination where the nascent root and shoot are subjected to a substratum far less favorable to growth than those of the seed pan. Again, the transplanted seedlings were practically free from the inter-specific and intra-specific competition which must be intense in nature. The detection of a conspicuous selective death rate under such optimum conditions can leave little doubt as to the force of natural selection under the severe conditions in which plants grow in nature.

Pigmentation in Man in Relation to Selection.[39]—The problem of

[37] J. Arthur Harris, "A Simple Demonstration of the Action of Natural Selection," *Science*, N. S., 36: 714–715, 1912.

[38] These comprise about ten "pure lines" each. The fact that the mortality of normals and abnormals tends to rise or fall together has no necessary significance for heredity. It is probably due, largely at least, to the fact that the two kinds of seedlings were under the same environmental conditions.

[39] So nearly all the work on pigmentation which falls in the scope of this paper has been done on man that a more general heading seems unnecessary. About the only other case for mammals is that suggested by the anomalous behavior of yellow in breeding experiments with mice. The problem has been

the relationship between the pigmentation of the hair and eyes of the individual and his mental characteristics, his bent towards criminality, his health and his capacity for survival has received the widest discussion.[40]

The relation of pigment to selection has been discussed chiefly from two points of view—that of urban selection[41] and that of susceptibility

As early as 1904 Pearson,[42] working with Pfitzner's data for Lower Elsass, suggested that the high correlation between age and pigmentation in the case of post mortem cases is more nearly explained by a selective death rate of the lighter types than by the assumption of a darkening with age alone. In the same year appeared a most suggestive paper by Strumball,[43] who attempted by the comparison of hospital censuses with the general English population to ascertain whether susceptibility to various diseases is dependent upon the anthropometric characteristics of the individuals affected. He concluded that blond features are associated with acute rheumatism, heart disease, tonsilitis and osteo-arthritis, and that the brunette traits are associated with nervous diseases, tuberculosis and malignant diseases.[44]

MacDonald[45] finds that for scarlet fever, diphtheria, measles and whooping cough among Glasgow school children recuperative power is

discussed by Cuénot, Little, Castle, Morgan, Bateson, Wilson, Durham and others. Apparently, no one has succeeded in finding a mouse pure to yellowness. The suggestion has been made that two gametes both having the determiner for yellow are incapable of uniting in fertilization or that they are not viable if they do unite.

[40] To mention even the chief of these papers, the most of which are based on data or methods inadequate for conclusive results, would require too much space.

[41] Anthropologists have devoted much attention to the highly complex problem of the difference in pigmentation between urban and the surrounding rural populations. Ripley in his "Races of Europe" gives a good general discussion. to disease.

[42] K. Pearson, *Biometrika*, 3: 464–465.

[43] F. C. Strumball, "Physical Characters and Morbid Proclivities," Saint Bartholomew's Hospital Reports, 39: 63–126, 1904.

[44] Of course, general suggestions and some statistical work precede Strumball's work. To many of these he refers. More recently, in a discussion on "Heredity and Disease" (*Proc. Roy. Soc. Med.*, 2[1]: 96–98, 1908), he returns to some phases of the question and concludes that the onset of tuberculosis is earlier in blondes, but that the disease is more frequent in dark types.

[45] D. MacDonald, "Pigmentation of the Hair and Eyes of Children Suffering from Acute Fevers, its Effect on Susceptibility, Recuperative Power and Race Selection," *Biometrika*, 8: 13–39, 1911. Here he has brought together a detailed review of the earlier theories and evidences. While his résumé is restricted to writings by those of scientific standing, the diversity of results show that much of what has been authoritatively laid down is nothing more than casual observation and vague suggestion.

associated with hair color and eye color in such a way that the darker classes have the greater recuperative power.[46]

Pearson[47] has also demonstrated correlation of $r = .19$ between health and hair color and $r = .07$ between health and eye color for data relating to 2,317 boys. Similar results were obtained for girls.

But, on the other hand, there are contradictory evidences. For instance, the conclusion reached by Saunders[48] from his study of pigmentation and susceptibility to diseases in Birmingham school children is that pigmentation is not a factor in selection.

He also finds that relationships between pigmentation and stature and weight, if they exist, are of so delicate a nature that much more refined data than those furnished by the ordinary anthropometric surveys or school medical officer's reports are necessary for their detection.[49]

The discrepancy between his results and those of MacDonald is possibly due to differences in the nature of the populations dealt with. Perhaps, too, data derived from the official examination of school children are less reliable than the hospital returns.

Woodruff has attacked the problem of the relationship of pigmentation to selection from an entirely different, and most important, side.[50] He seeks to determine the relationship between skin color and survival in tropical sunlight. He concludes that the lack of pigmentation is

[46] These conclusions rest solely on the hospital observations. I omit those which involve questions concerning the liability to infection, since they require a knowledge of the distribution of pigmentation in the general population. Such comparisons involve the use of some such basis as the British Association standards or the general anthropometric surveys, which may not be valid for the particular district or social class from which the hospital or asylum inmates are drawn. This was true, for instance, in Strumball's pioneer study, which is highly suggestive rather than conclusive. Again, in attempting to settle the question of differential incidence by an analysis of hospital populations there is the danger of a large personal equation in the appraisal of non-measurable characters. Neither of these difficulties are met when studies of recuperative power are made by a single observer. See also K. Pearson, *Biometrika*, 8: 39, 1912.

[47] Unpublished results quoted by Saunders, *Biometrika*, 8: 355, 1912.

[48] A. M. C. Saunders, "Pigmentation in Relation to Selection and to Anthropometric Characters," *Biometrika*, 8: 354–369, 1912.

[49] Miss Elderton, "On the Relation of Stature and Weight to Pigmentation," *Biometrika*, 8: 340–353, 1912, concludes from her study of the relationship between hair and eye color and weight and stature: "So far as the material goes we find that types of hair and eye color are not associated to any substantially significant extent with divergencies in height and weight in children between the ages of seven and fourteen, inclusive." It must be noted that Miss Elderton's problem was in large part undertaken to determine the influence of racial heterogeneity on stature, in its relation to environmental influence.

[50] Chas. E. Woodruff, "The Effect of Tropical Light on White Men," 1905. Also, *Science*, N. S., 31: 620, 1910.

an immense barrier against the penetration of the blond races into the tropics.[51]

Summarizing in a word the results of these studies on man, we may say that the death rate is unquestionably selective. There are still those who assert that while natural selection applies to the lower organisms its force is *nil* in civilized society. Against such a view the evidence of biometric workers seems fairly conclusive. But concernng the way in which this selective death rate occurs we know lamentably little. Indeed, the whole problem of the basis of natural selection in man is open to investigation. The biometric work which has been done shows how complex the whole problem is, and how idle to attempt its solution by any means but the analysis of large masses of carefully collected data by refined statistical methods.

III. Supplementary Tests of Fitness

The capacity of an individual for survival is doubtless dependent upon the fitness of its several organs for performing their respective functions, or upon the nicety of their coordination. At present, the ultimate goal of investigations of natural selection would seem to be the determination of the significance for survival of each deviation from type of as many organs or characteristics as practicable. Upon the evidences afforded by a comprehensive series of investigations of this kind must depend our final views concerning the significance of natural selection as a factor in organic evolution.

Fitness may be tested in various ways. A series of individuals may be actually subjected to a struggle for existence—be "exposed to risk," to use an actuarial term—and the difference between the series of individuals which survive and those which perish measured in terms of biometric constants. This is essentially the course followed in the studies reviewed in the preceding paragraphs. It is from the standpoint of the evolutionist the most direct method.

Fitness may, however, be tested in some favorable cases in which the individual lays down a series of organs (with measurable characteristics) only a portion of which may develop to maturity. Here one may find that the elimination of organs within the individual is not random, but selective. A comparison of the characteristics of the organs which fail with those which complete their development may furnish information as to the characteristics which make for fitness or unfitness for survival.

Again, physiological criteria—*e. g.*, efficiency in the maturing of

[51] One should also read the most interesting chapter on the problem of the white man in the tropics in Ripley's "Races of Europe." There, structural characteristics as well as pigmentation are considered.

ovules into seeds, or in the formation of well-developed seeds—may be found.

Obviously, it will be of great advantage if direct demonstrations of the action of natural selection can be supplemented (or in some cases it may be preceded) by evidences of an entirely different sort.

Such supplementary evidences have so far been sought only in the case of the organization of the plant ovary. Studies of the selective elimination of ovaries have been reviewed in the earlier paper on the measurement of natural selection.[52] Since then considerable side light has been thrown upon the problem of the intra-individual selective elimination of organs by two studies of a purely physiological character.

One of the characters dealt with in studies of the development of the ovary is the "odd" or "even" number of ovules which it produces. This is essentially a criterion of the bilateral asymmetry of the plate of carpellary tissue giving rise to a locule. In large series of pods of garden beans it has been shown[53] that pods with an "odd" number of ovules—that is, those which have the ovules unequally divided between the two carpellary margins, and are consequently bilaterally asymmetrical—are less capable of maturing their ovules into seeds than are those with an "even" number. Again,[54] all the available data indicate that the weight of the seeds is lower in pods with an "odd" than in those with an "even" number of ovules.

The interest of these results is heightened by the fact that the type of structure which in *Staphylea* shows an inferior capacity for development, in *Phaseolus* shows (by two different tests) a physiological inefficiency. As soon as proper materials and technique are available it will be of importance to consider asymmetry in its relation to the capacity for survival of the individual.

[52] The soundness of the conclusions of the papers there reviewed has been emphasized by a research which has appeared since that time ("Further Observations on the Selective Elimination of Organs in *Staphylea*," in *Zeitschr. f. Ind. Abst.- u. Vererbungsl.*, 5: 273–288, 1911). Here it is rendered highly probable that the observed selective mortality of ovaries can not be explained by such simple factors as a correlation between the position of the ovary on the inflorescence, with a heavier but purely random mortality in certain regions of the inflorescence. In another paper on methods ("On the Formation of Condensed Tables when the Number of Possible Combinations is Large," *Amer. Nat.*, 46: 477–486, 1912) evidence is brought forward for an interesting morphogenetic relationship between radial asymmetry of the compound ovary and its locular composition.

[53] J. Arthur Harris, "On the Relationship between Bilateral Asymmetry and Fertility and Fecundity," *Roux's Archiv. f. Entwichelungsmechanik*, 35: 500–522, 1912.

[54] J. Arthur Harris, "On the Relationship between the Bilateral Asymmetry of the Unilocular Fruit and the Weight of the Seed which it Produces," *Science*, N. S., 36: 414–415, 1912.

IV. Concluding Remarks

A summary, properly so called, of the materials of this paper is precluded by the fact that the various sections are in themselves summary reviews of researches carried out upon the most diverse materials. But all these studies have this in common: they are attempts to determine by quantitative methods whether natural selection be a reality, and if so, to measure its intensity. In conclusion, stress may be laid upon two points.

The first of these is a matter of fact. Evidences of the occurrence of natural selection for many characteristics are rapidly accumulating. That mortality is not random, but differential, and that the intensity of the selective death rate is a problem open to quantitative treatment, are propositions supported by large bodies of sound scientific evidence. Nevertheless, neither the complexity of the phenomena nor the difficulties of the collection or of the analysis of the data can be underestimated. As yet, only the surface has been touched. The results are all subject to such revision as may be rendered necessary by wider data and narrower analyses.

The second of these is a question of interpretation. The demonstration of the existence of a selective death rate in a given case is by no means equivalent to proof that evolutionary change is taking place in the character under consideration. Natural selection may only maintain a characteristic at the stage already attained. Or the force of natural selection may be offset by that of some other factor. Or, again, the variations dealt with may be of a kind not inherited; and without inheritance selection is powerless to effect any change. Indeed, first-hand experience in quantitative work on organic evolution must convince any one that the problem of the methods by which it has taken place is far more recondite than biologists have been wont to consider it. This great complexity demands an attitude of extreme caution in generalization. For the present, we must be content to attempt to measure one possible factor after another in as wide a series of organisms as possible. Having done this, we may hope in time to form a fairly trustworthy conception of the resultant of these forces as they may be combined in nature.

THE HIBERNATION OF CERTAIN ANIMALS

By the late WALTER L. HAHN, Ph.D.

THE hibernation of animals is one of the most interesting phenomena of nature. The word "hibernation" comes from the Latin *hibernare,* meaning to go into winter quarters, but it has come to have a more restricted meaning, and we understand by it a protracted condition of lethargy, during which the vital activities of an animal are more or less completely suspended.

Some of the simplest or one-celled animals, the *infusoria,* have the ability to withstand extremes of cold and drouth for long periods by forming hard coverings or cysts about themselves and in this condition they may be completely dried up and blown about by the wind, reviving when favorable conditions return, perhaps months afterward.

This condition corresponds to the hibernation of higher animals about as closely as any of the other activities of these simple organisms correspond with the more complex life of the higher species.

As far as I have been able to learn, there is nothing corresponding to hibernation in those animals that are nearest the *infusoria* in the scale of life, the sponges, corals, jelly-fishes, starfishes and the hosts of other marine invertebrates. However, practically all insects in temperate climates (excepting some that live in the water) pass the winter in a dormant state. In some species the adult insect lives through the winter, in others only the eggs, the larvæ or the chrysalides survive. In some cases the insect burrows into the ground or seeks protection elsewhere; in others, the egg, larva, chrysalid or adult insect remains in the most exposed situations in temperatures at times many degrees below freezing point.

Without attempting to enumerate all the kinds of animals that hibernate or to discuss the general features of the phenomenon, I shall merely call attention to the well-known fact that frogs, toads, snakes, lizards and turtles, in temperate climates, seek protection during the winter months in crevices among rocks or buried in the soil or mud according to their especial habits. We will now pass on to a discussion of the hibernation of certain well-known species of the highest class of the animal kingdom, the mammals.

The Bears

I mention the hibernation of the bears here, not because I have any new facts to contribute in regard to it or any personal observations to record, but because that while the general fact of their hibernation is

well known, their hibernation presents many less well-known and peculiar features.

In the first place, bears are the largest animals known to hibernate, and the only members of the great order *Ferœ*, or flesh eaters, that do so. However, all the species of bears do not hibernate. Some that inhabit tropical Asia are active at all seasons and, according to the testimony of many artic explorers, the polar bear is also.

Grizzly and black bears in the United States generally remain active until after snow has fallen and severe weather has begun, that is to say, until the end of November or later. There seems to be a great individual difference in this regard, however, and there are records of bears being seen in all months of the year. Whether those that are abroad in midwinter have been disturbed in their winter sleep or have never gone into winter quarters, I am unable to say.

In some parts of the country there was a belief among the pioneers that bruin swallowed a knot of wood before entering upon his long fast, the purpose being to nourish him or "to keep his stomach from shrinking."[1] How this absurd notion arose, I can not conjecture. The bears, like most other animals, become very fat in autumn when food is plentiful, and the fat is gradually resorbed by the blood and carried wherever it is needed in the body. The animal requires much less food while dormant than when active and there is nothing especially mysterious or unusual about its nutrition during this period. Neither is there any more reason why its stomach should "shrink" than that ours should shrink when we occasionally abstain from eating on account of sickness or any other reason.

The most remarkable fact in connection with the hibernation of the bears is the birth of the young during this period. With the black bear this occurs in January or February and the mother remains in her den for six weeks or two months longer. The young are generally two in number, sometimes one and sometimes three. It must be a tremendous drain upon the vital resources of the mother to nourish her offspring at the conclusion of this long fast and she would be wholly unable to stand it if it were not for the small size of the young which weigh only a few ounces at birth and find an ample resting place upon the palm of a man's hand.

The Woodchuck

This animal is better known in some parts of the country as the "ground hog." Its appearance is familiar to most people, but it is not so generally known that this clumsy, short-legged, short-tailed inhabitant of underground burrows is a member of the squirrel family, as is the prairie dog of the western plains.

[1] I do not know how widespread this idea may have been, but I heard it as a boy in southern Indiana, 40 years or more after bears became extinct there.

Unlike the bear, the woodchuck is exclusively vegetarian in diet. A favorite food is red clover, but it also eats apples, berries, grass, growing grain, nuts, bark and tender twigs of trees and shrubs; and it seems to have a peculiar fondness for the green leaves and twigs of the sassafras. During the spring and early summer these animals wander about, when their family duties permit, and consume great quantities of food. By September they have become very fat, and instead of going out two or three times a day to feed, they probably do not go out more than once, and when the days become chill, not that often. The time at which they begin to hibernate doubtless varies with the locality and the individual animal. In southern Indiana, where most of my own observations have been made, they retire about the end of October, or when the acorns and beech nuts are falling and the forest's red and gold is giving way to brown.

As to the condition of the animal during its long period of torpor, I know nothing. It is said to retire to a lateral chamber in its burrow, where it shuts out the cold air by filling the entrance with earth. There it remains for about five months, eating nothing, probably very cold and with its circulation and respiration reduced to a minimum.

In many parts of the country there exists a curious superstition (I know no better name for it) that "the ground hog" comes out from his winter's sleep on February second, and if the sun shines forth so that he can see his shadow he will retire to his hole and stay there six weeks longer, and there will be six weeks more of winter weather. There is doubtless some connection between this date and Candlemas day, for there is a stanza of an old poem, the origin of which I do not know, that begins:

> If Candlemas be fair and bright
> Then winter will take another flight.

How the "ground hog" came to be connected with Candlemas remains a mystery. The late Professor Otis T. Mason, of the Smithsonian Institution, an authority on American folk lore, told me a few years ago that he had no idea where the "ground-hog day" fable originated, and he also stated that it is, or was, unknown south of Mason and Dixon's line.

There has been a dispute in some quarters as to whether "ground-hog day" is really the second day of February or the third. To settle the matter, a bill was introduced into the legislature of a certain state a quarter of a century ago to appropriate two thousand dollars to defray the expenses of a scientific commission that should investigate the matter and settle the dispute for all time. The bill did not become a law. Perhaps it is on this account that the perverse "ground hog" refuses to come out on either of these dates. The exact time of awaken-

ing from his prolonged sleep probably depends somewhat upon the temperature, but this remains to be proved. The earliest that I have known ground hogs to come out was the third week in February in the extremely warm season of 1907 in the region already referred to—southern Indiana. They seemed all to emerge at about the same time, for I saw a number of places where earth was thrown out of their holes and their tracks were left in the soft clay, although it was two weeks later before I saw any of the animals, for they are extremely wary and active at this season. When they first break their long fast they are very thin and eat twigs, grass or almost any tender herbage that can be found. Perhaps it is on this account that they pay no attention to cold when once out. In the year in question we had cold weather and several inches of snow about two weeks after I noted the first signs of woodchucks; but it failed to keep them in. Mating time is then at hand and this, no doubt, is an additional incentive for them to remain active.

Bats

Bats are more numerous in tropical and subtropical countries than in cooler climates. They do not hibernate there, although the presence of large numbers of some of the species in certain caves suggests that they may remain there for days at a time without going out to feed.

Bats are capable of flying very rapidly for a considerable length of time and it is not surprising that some species living in temperate climates migrate southward in winter. As far as we know, this habit is limited to three or four species in northern North America. These have their summer homes in trees throughout the wooded region from the Ohio River to Hudson Bay and migrate southward to spend the winter in the Gulf States. Whether they also hibernate for a time, I am unable to say.

The most conclusive evidence of their migration is the fact that they have never been found in the northern limits of their range in winter, and seldom or never in the southern limits in summer. In a few instances their southward flight in early autumn has been observed. The northern range of these migrating species is occupied by six or eight other kinds of bats that are not known to migrate regularly. These hibernate, chiefly in underground caverns, but sometimes perhaps in attics, deserted buildings and stone walls.

I have studied the hibernation of these animals in the limestone caves of southern Indiana. Other species have been studied in Europe, but what I shall say here is based almost entirely on my own observations.

A bat in normal sleep rests with head down, suspended by the pointed and curved claws which are hooked about some small protuberance, such as a rough place on the bark of a tree or a rough stone; the

wings are folded along the sides. Sometimes the body rests against a vertical surface and a pair of claws (they are really the animal's thumb nails) on the wings help to support the weight. More often the animal hooks its claws to the rough stone ceiling of a cavern and does not touch a solid support with any other part of its body. The body sways gently back and forth as the animal breathes, and its breathing is rapid. It is easily awakened by a touch, a noise or even by bringing the heat of a candle near it. The parts that are not covered by hair feel warm to the touch.

The hibernating animal is found in the same locations and the same attitude as the sleeping animal. It does not sway with a regular rhythm, and if you give it a mere cursory examination you may be convinced that it is not breathing. However, a longer observation will show that at irregular intervals, perhaps minutes apart, it will respire in a convulsive manner for a few times and then become quiet. It is not easily disturbed by a noise or by warmth. If you rudely snatch it from its place and then release it, the animal is absolutely helpless and falls to the ground with wings still folded. The hairless parts of its body are cold to the touch.

However, a severe disturbance will arouse it, no matter how soundly it sleeps or at what season it may be. It then begins to breathe, not rapidly nor regularly at first, but with so much violence that it seems as though the whole body will be torn to pieces. The wings and legs move spasmodically and the temperature rises rapidly. In a few minutes the bat is wide awake and active. Between the two extremes of light sleep and deep torpor, every gradation exists.

Between April and August bats rarely enter the caves. During this period they rear their young, spending the days in trees and out-of-the-way nooks and crannies, and the nights in chase of insect food. Some time during August they begin to return to the caves in considerable numbers, and during this month I have found many of the animals as torpid as at any time during the year. In every instance the torpid animals were exceedingly fat. This should not be understood as implying that these creatures remained in this condition without taking food until April. Indeed I am very certain that this was not the case, but the reasons for so thinking will be developed later.

By the first of October it is probable that all of the bats have deserted their colder outdoor retreats and have come into the caves, but even now all do not remain continuously, but some go out to search for food when the nights are not too cold. I have not seen them out later in the season than the middle of November, but it is not improbable that some may venture out at any time during the winter if balmy nights occur.

During the late autumn the greater number are found in the large

interior chambers of the caverns, half a mile or more from daylight, and not, as a rule, in dense clusters, although thousands may be hanging on a few square yards of rock. The positions of a number of bats were marked on the roof of a low chamber early in October. A week later about one third had moved, two weeks later half had moved and at the end of a month not one remained in its original position. By the end of December this chamber was entirely deserted and its occupants were scattered and were, for the most part, in higher chambers, where they were difficult of access.

The first week in January was very warm, and at this time I found many of the animals clustered near the cavern entrance. There is little doubt that some of them went outside, but they are unfitted for securing food that is concealed and they probably found few, if any, insects on the wing after nightfall. A sudden drop in temperature a week later was accompanied by a rush of cold air into the caves, and this scattered the bats and sent them into the inner recesses where the temperature is very nearly constant the year round. During February they again began to congregate near the entrance and the numbers increased and diminished irregularly until late in April, when they rapidly diminished as the bats left the cave for the season.

This, in brief, is the winter life of the cave bats. It begins, with some individuals, in August but is interrupted before winter begins. During the winter they move about to some extent and become more restless at the approach of spring, but are not able to get any considerable quantity of food until warm weather begins in earnest, usually in April.

The torpid condition of hibernation is induced by abundance of food and is not dependent on cold weather. The animals can be awakened from their lethargy at any time by mechanical disturbance alone. They are also made active by hunger after most of their fat is absorbed, but the end of their fast is determined directly by food supply and indirectly by weather conditions.

The Thirteen-lined Ground-squirrel

This animal is an inhabitant of the upper Mississippi Valley from Indiana to the Rocky Mountains. It is better known as the "striped gopher" but the gophers are very distinct, zoologically, while this species, as its name implies, is a squirrel.

It is closely related to the familiar chipmunk of the east, which it resembles in size and habits, although it is more slender of build and differently colored. In the region where it abounds it lives on the lawns, in the orchards and pastures, along railway embankments, and, in fact, almost everywhere. Hence it is easier to study than the chipmunk, and this is the reason for selecting it in preference to the more familiar eastern animal.

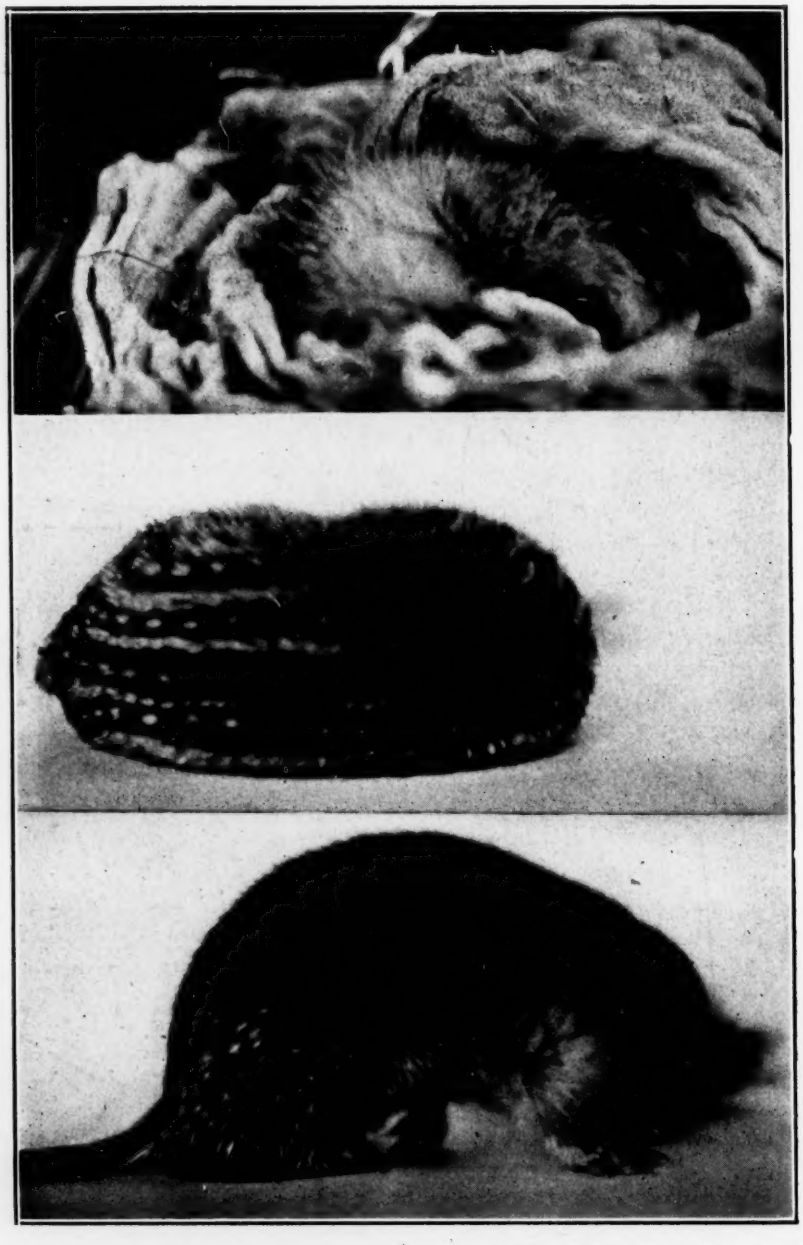
The food of this ground-squirrel consists of a few grasshoppers, crickets and beetles, some grass blades and other tender leaves and growing tips, a few roots and a very large proportion of grains and other hard seeds. Soft fruits, apples and berries are not despised, but seeds must be regarded as the staple diet of the animal.

The home is an underground chamber, reached by a hole going down almost vertically for about a foot and then turning horizontally and ramifying into two or more passages. Generally there are two or more vertical passages connecting the burrows with the outer world. The young are born in these subterranean homes some time during the early summer. The family breaks up in the late summer and apparently the young make new burrows for themselves and the animals hibernate singly, but of this I am not sure.

Hibernation begins at the onset of cold weather. The exact date of their final retirement to winter quarters varies with the season, the locality and the individual, and yet there is a certain amount of uniformity about it. Thus in 1909 in southern South Dakota there was no frost until October 9 or 10, when the temperature suddenly dropped and on October 11 it was several degrees below freezing point with a bitter northerly wind that made it seem much colder. Until this "cold snap" I had seen ground-squirrels daily. Afterward, there was a period of three or four weeks of very balmy weather, but I did not see another ground-squirrel although I had excellent opportunities had they been active.

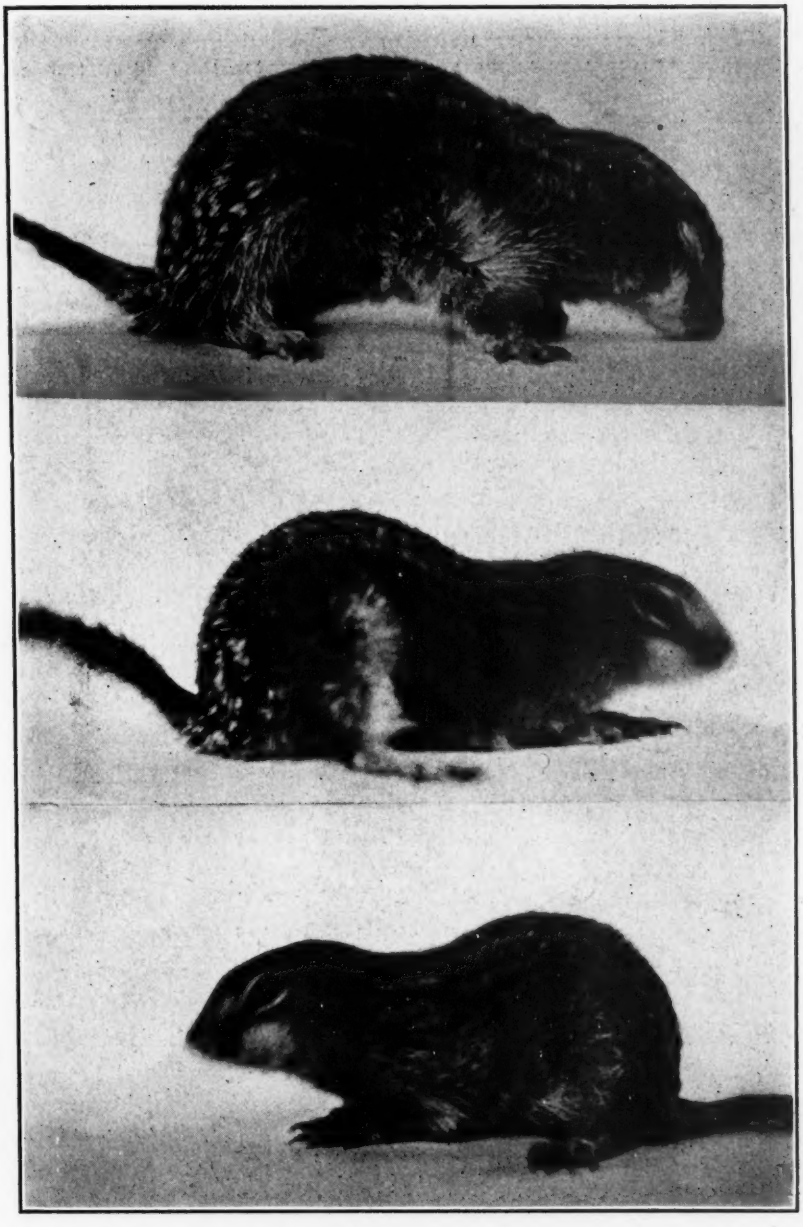
The end of their hibernating period varies somewhat and it probably depends somewhat upon the temperature. On the banks of the Missouri River, in South Dakota, the first of these little animals are usually seen whisking about their burrows some time late in March. Usually a number are to be seen on the same day that the first one appears. In this they show a striking similarity to the woodchuck as they also do in their habit of staying out in all kinds of weather, once they have made the venture. Thus in the spring of 1910 in mid-April we had a snowstorm lasting two days and piling the snow up three feet deep in places. The very day that the storm subsided I saw ground-squirrels running cheerfully about, buried to their hips in snow.

A captive animal of this species afforded opportunity for a very interesting winter study. He was captured in an insect net in September and placed in a wooden box which had a front of fine wire mesh. He was fed corn, small grains, potato, apple and sweet potato. Water was given him also but he did not seem to use any of it and I finally ceased to give it. The small grains were the favorite food and he would not eat the outer part of the corn grain unless driven by actual hunger although the heart (embryo) of the grain was gnawed out. The cage was kept in the supply closet of my laboratory. The former was without



AWAKENING FROM HIBERNATION

Thirteen-lined ground squirrels dormant in nest.
Removed from nest, but still dormant.
Waking; head moved convulsively.



OF THE THIRTEEN-LINED GROUND SQUIRREL.

Becoming more steady.
Nearly awake; head and tail still quivering.
Wide awake and active.

a window or heating device, but the door into the laboratory was open a part of every day. While the closet was dark the animal slept; when lighted, it was active for several hours a day, but always went to sleep when the early shadows began to fill the room. On the back of the cage there was a small door which was fastened by a pivot and opened by lifting one corner. It was not long until the little creature learned to open the door and forage for himself. His curiosity was insatiable and he climbed all over every part of the laboratory and carried back to his cage everything he could find in the way of food, as well as a quantity of rags kept for cleaning laboratory apparatus, but which he used to make a nest for himself.

His quarters were, of course, warmer than those of his brothers out of doors and I at first thought that he would not hibernate, but the heat was allowed to go down over Saturday and Sunday and in December when the temperature fell below zero outside, the room temperature reached freezing point or lower. The first time this happened, I missed the customary recklessness of my little pet on Monday and at first thought that he had escaped or was dead. But a closer examination showed that he was asleep inside the mass of cotton, rags and paper that composed his nest and with a heap of half-eaten kernels of corn by his nose. His body felt cold, and lay inert in my hand when I unwrapped him and I put him back again after covering him up as he was before, but did not fasten the door he had learned to open. The next morning I gave him no attention and it is difficult to say which was discomfited the most, myself or the class, when he scuttled across the laboratory floor and under a table where four girls were working, paused to sniff at some seeds that had been dropped by a class in botany and then darted to a well-known place of concealment behind a large stationary cupboard.

He did not take another prolonged sleep until I left for the Christmas holidays. During vacation the fire was again allowed to go down until there was just sufficient to keep steam pipes from freezing, and I was not surprised to find him dormant at my return. This time I determined to allow him to continue his winter's rest, so I kept the only door of the closet shut and the temperature remained fairly constant at a few degrees above freezing, perhaps falling to freezing point on Saturday and Sunday, for the walls separating the closet from the adjoining rooms were thin and the temperature within them changed slowly. Under these conditions, the sleep was prolonged somewhat more than a month and its termination coincided with a period of warmer weather. However, that did not end the hibernation of the animal, for several times afterward he slumbered soundly for a few days at a time. Each time he awoke he ate heartily and was quite active. When asleep it was possible to awaken him by taking him up into the hands and stroking him or handling him roughly.

At such times the first visible indication of awakening was a more rapid and convulsive breathing. This was followed by slow and feeble movements like those of a helpless young animal. Finally he opened his eyes, then took a few steps and soon fully regained his powers of motion.

This awakening is well illustrated by the accompanying photographs, which are presented, not as good examples of the photographer's art, but as poor photographs representing a subject which I believe has never before been illustrated. I have not been able to duplicate the series, which was taken under difficulties, as the day was dark for indoor photography and I had to work in a cold room. In addition to this, I had no idea of getting anything more than a single picture of the sleeping animal when I began and hence was unprepared to take a series and had to work rapidly. The series covers a period of about twenty-five minutes.

SOME ABNORMALITIES IN APPLE VARIATION

By W. J. YOUNG

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IF one were to enumerate the chief characteristics of the apple, its variability would doubtless come well toward the head of the list. A species which has been so long under domestication, which has been removed to so many localities where it is not native and subjected to conditions so different from those of its original habitat and which has such a complex ancestry as our modern apple, may well be expected to display a great variety of forms, and among the number some of such abnormal character and infrequent occurrence as to be reckoned as curiosities. It is not my intention in this article to discuss the variation of the apple in general, but only to jot down some notes concerning a few such freaks as have come to my attention during the past season.

First of all, I wish to consider some curiosities of apple coloration. It is pretty generally understood that, other conditions remaining the same, the color of an apple depends to a great extent upon the amount of sunlight to which the fruit has been exposed. The apples grown on the shady side of the tree are apt to be somewhat poorly colored, and the shady side of an apple itself is nearly always less highly colored than the side exposed to the direct rays of the sun. Every one is familiar with the nicely contrasting light spots which are common on our dark red apples where they have been shaded by some friendly leaf, and such spots, if not too extensive, are usually regarded as adding to the attractiveness of the fruit. This effect of sunlight and shadow upon the color of an apple is so well understood that it is often made use of in printing various designs upon the surface of the fruit. It is not often, however, that an effect of this kind is produced wholly without intention, yet that such a thing may happen is shown in the illustration. This specimen of nature's color photography represents a leaf with petiole, midrib and marginal teeth. The apple is of the McIntosh variety and is one of a number which resulted from artificial cross pollination. In order to prevent the loss of the apples in case they should drop from the tree before picking time, they were enclosed early in the season in small sacks of mosquito netting. This particular specimen happened to so press against the interior of the sack that a leaf was held firmly against its side, and the nearly perfect print of the leaf was the result. The

faint lines which appear in the dark portion of the surface are the prints of the threads forming the sack.

Though the effect of the sunlight upon the color of apples is so well known, the nature of the pigment formed and the changes which it may undergo are not well understood. It is apparent from chemical studies that iron is present in its composition and this has led to the belief in some quarters that a soil rich in iron compounds is a factor of prime importance for the production of highly colored fruit. As a matter of fact, iron is also necessary to the production of chlorophyll in the leaves,

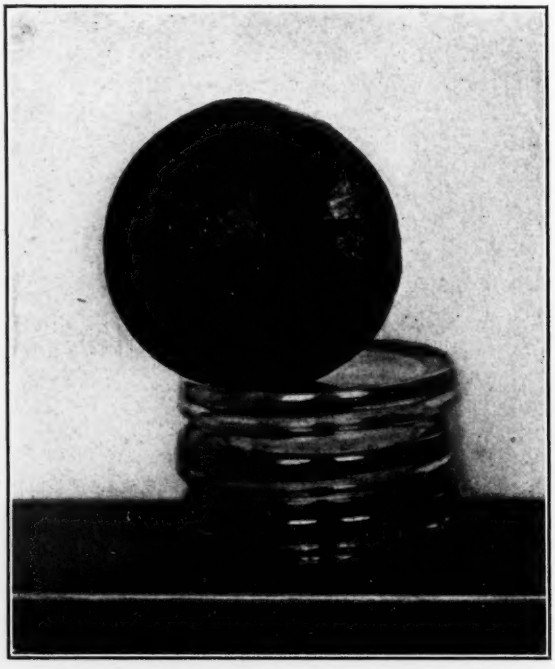
PRINT OF A LEAF UPON THE SURFACE OF AN APPLE ABOUT ONE HALF NATURAL SIZE.

and since the ash of the leaves contains a larger proportion of iron than that of the fruit, it seems fair to suppose that soils containing sufficient iron for proper chlorophyll development also have an abundance for the formation of pigment in the fruit.

Even more obscure are the causes which lead to the formation of pigment in certain varieties while it is absent or nearly so in others. While the color is no doubt greatly influenced by heredity, this fact takes us but a short step nearer the solution of the problem. It was formerly held that not only the color but also the form, size and flavor of an apple might be greatly influenced by the variety furnishing the

pollen with which the blossom is fertilized. This theory is generally discredited at the present time, as well authenticated instances of such direct effect of the pollen are lacking in the case of the apple. The direct effect of pollen upon the color of the fruit is the rule in corn, as is well known, and it is not impossible that it might sometimes be manifest in the apple, though proof of that fact is lacking. At any rate, specimens are sometimes found which strongly suggest the direct influence of the pollen, and it has been my fortune to examine a half dozen such apples last season.

The first to come to my attention was grown in the Lake Chelan locality and appeared to be a small specimen of the Ben Davis type.



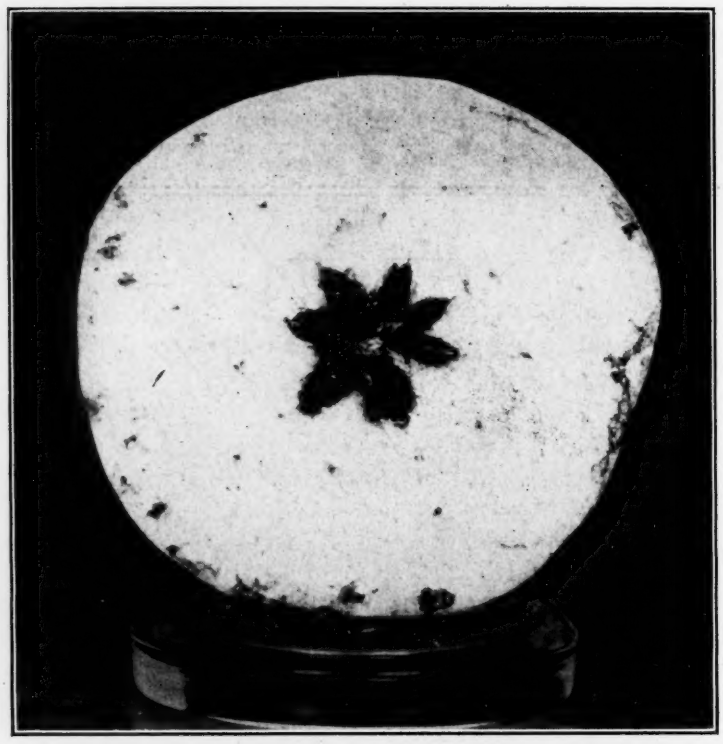
PARTICOLORED APPLE USUALLY ASCRIBED TO BUD VARIATION BUT SOMETIMES REGARDED AS SHOWING THE DIRECT EFFECT OF POLLEN. About one half natural size.

It had been picked for some time when received and was badly shriveled. The larger part of the surface of the apple was greenish indistinctly striped with red. A segment, however, covering about two fifths of the surface was of a very dark color with scarcely a suggestion of striping. The lines of demarcation between these dissimilar portions of the surface were clearly and sharply marked, as shown in the illustration, and extended from stem to calyx. Upon cutting the apple, it was found that the dark portion of the surface just covered two of the carpels or divisions of the core. This portion contained three perfect seeds, while there were five seeds in the remainder of the core.

The second specimen of this kind was a McIntosh apple from the experiment station orchard. In this case the larger portion of the surface was of the normal red color of the variety, but a segment of about one third of the surface was very light in color, faintly streaked with pink. The two sections of the surface were clearly marked off from each other, though the lines of demarcation were not quite so sharp and regular as in the specimen already described. The light-colored segment covered approximately two carpels of the core, although the open nature of the McIntosh core made it more difficult to determine that point accurately in this apple than in the other. Each part of the core contained four seeds. Two of these were abnormal and will be described farther on in this paper.

A poorly colored apple of the Arkansas variety received from White Salmon had a brownish red band extending from stem to calyx, covering a fifth of the surface. On the opposite side of the apple was a similar streak, but only about an eighth of an inch wide. The dark portion included one carpel containing a single seed, while the remainder of the fruit contained but one good seed. A Winesap from the Yakima Valley had on the lighter-colored side a deep red stripe covering about an eighth of the surface and including one carpel. This portion of the core contained one seed while there were seven seeds in the remainder of the fruit. A Rome grown at Pullman had half of the surface of a nearly solid red color, the remainder being green with red splashes. The lighter portion contained three seeds and the dark part two. A second specimen of Rome from Pullman had a dark area covering two carpels, an area of moderately light color, also covering two carpels, and a still lighter portion covering one carpel which was seedless. The other portions contained three seeds each. The seeds from the differently colored portions of all these apples were saved separately and planted in the hope of obtaining some light in regard to the significance of such abnormalities.

Turning from freaks of color, we will next consider some apples of abnormal structure. The doubling of fruits or the multiplication of parts is a variation of less common occurrence in the apple than in some other species. Certain varieties of the plum, for example, ordinarily produce a fairly large proportion of double fruits. These result from the presence of two complete pistils in a single blossom. Analogous cases of polycarpy occur in the apple, though less frequently than in the stone fruits. Apples having six carpels have come under my notice in the Grimes, Rome, Gano, Delicious, Chelan and Yellow Newtown varieties, and I have observed blossoms of the Golden Sweet having six pistils. The Yellow Newtown seems especially prone to this kind of variation and a number of specimens were found the past season containing six carpels, and in one instance a fruit with seven carpels was noted. The



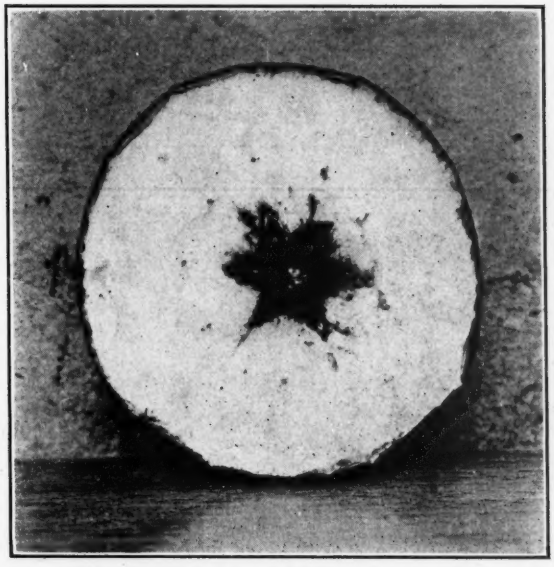
POLYCARPY IN THE APPLE. Yellow Newtown apple, having seven carpels. Natural size.

latter specimen had six calyx lobes, though the multiplication of carpels seems to take place as a rule independently of the other floral organs. An extra sepal, or possibly a bract, below the calyx and on the side of the tube, is not so very uncommon on fruits otherwise normal in structure and persists in the fruit as a scale on the side of the apple, usually deforming it somewhat.

I have never observed the suppression of carpels in apples of the ordinary varieties, though it may occur in some of the so-called seedless or coreless forms. In case one or more of the pistils fail to receive pollen while the remainder are successfully pollinated, the corresponding carpels appear always to develop more or less with the growth of the fruit, though they remain empty.[1]

Double apples, though comparatively rare, have occasionally been described and two such fruits were found at Pullman last season, one in the orchard of the experiment station, the other in an orchard adjoining the college campus, while a third was received from Wenatchee.

[1] Since these notes were written a student has discovered specimens of the Rome and Gano varieties having four carpels and very rarely three carpels; also seven carpels in the latter variety.

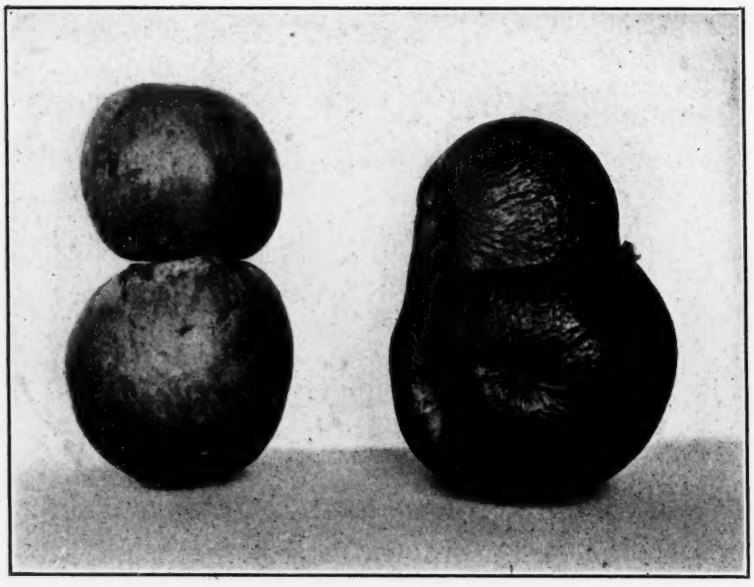


POLYCARPY IN THE APPLE. Grimes' apple having six carpels. Slightly reduced.

The first, a specimen of the Ben Davis, consisted of two nearly independent apples united for only a short distance near the base. The stem, originally single, had been split nearly to the base, while that part of the fruit between the insertion of the stem and the point of union of the apples had been broken apart as the apples had developed at the base. The two portions, thus almost completely separated, had each developed into a nearly perfect apple, though of small size. The cores were perfect and the axes, which were nearly straight, extended in almost opposite directions.

The second specimen, a Jonathan, consisted of two apples of unequal size joined together throughout their entire length and marked off from each other only by a shallow groove. The single stem upon which the fruit was borne was split for a short distance as the two portions spread apart in growing. When cut open each section was found to have an independent core containing perfect seeds, although in the smaller part that portion of the core adjacent to the other part was undeveloped. The axes of the cores, moreover, were strongly curved away from each other. The specimen from Wenatchee was similar in all important respects to the one just described and further account of it will not be necessary. Both of the double apples grown at Pullman are shown whole and in section in the accompanying illustrations.

Double apples of this kind originate in a manner quite different from the double plums mentioned above. The presence on the mature apple of two separate calyx cups indicates that these apples were produced by distinct blossoms borne at the end of a single flower stalk. In

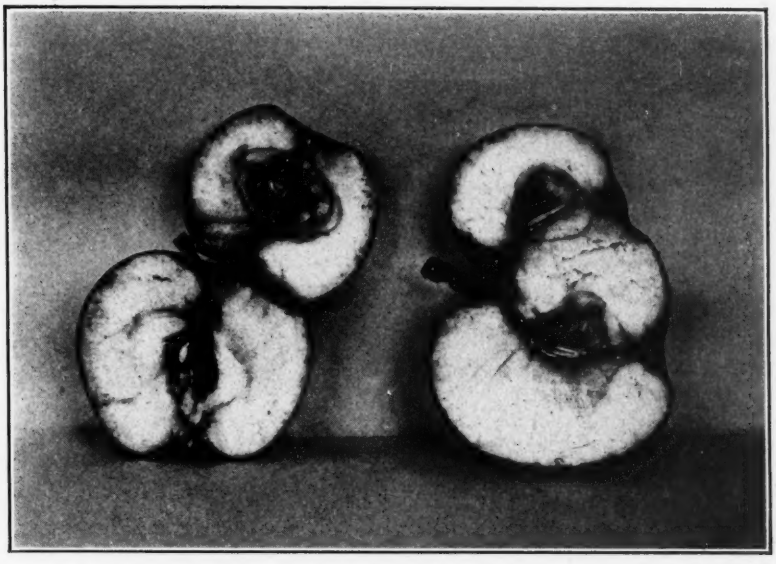


DOUBLE APPLES. About two thirds natural size.

the apples last described the receptacles of the blossoms must have been united nearly to the base of the sepals. In the first specimen, however, union appears to have taken place only at the base.

Polyembryony, or the multiplication of the embryos in the seed, is a condition normal in certain cases, notably in the citrus fruits and the Mango. Such seeds arise from ovules containing a single egg cell which gives rise to one of the embryos; the others originate as outgrowths, by a sort of budding process, from the inner wall of the embryo sack and of course reproduce the parent form as perfectly as other methods of bud propagation. True polyembryony must not be confused with the presence of more than one seed in an indehiscent fruit which normally contains a single seed. Such an occurrence is quite common in the peach and related fruits where the stone is really the endocarp or inner portion of the fruit and may enclose two seeds produced independently of each other, though the normal number is but one.

The carpels of the apple may contain from one to four seeds each, though the most common number appears to be two. I am not aware that a polyembryonic apple seed has been reported up to this time; however, one of the seeds in the abnormally colored McIntosh apple already described contained two embryos, while a second seed of the same character was found in another specimen of this variety. The manner of origin of these accessory embryos was not determined, though each embryo appeared to be surrounded by an independent inner seed coat. This fact would seem to indicate a method of production different from



DOUBLE APPLES. Section about two thirds natural size.

that of the polyembryonic seeds already noted, perhaps by a sort of fasciation or doubling of the ovule and the production in it of two distinct egg cells.

The seeds of the McIntosh apple appear, indeed, to abound in anomalous forms. Another seed in the same abnormally colored apple was remarkable for its small size, being perfectly formed, but of scarcely one fourth the length of an ordinary seed. Other seeds of this variety have been found in which the seed coat failed to develop and the embryo grew to full size without the usual brown covering, traces of which were found as a small patch at the hilum. An instance of this kind has also been noted in a seed of the Rhode Island Greening. In other cases the seed coats have split open as the seed developed, apparently as the result of the excessive production of endosperm which protruded as an irregular whitish mass containing the embryo. Though it is possible that such forms are the result of some unnatural state of nutrition in the seeds of this variety, nothing is known of the conditions which give rise to their production. Owing to the comparatively infrequent occurrence of abnormal forms, an investigation of their underlying causes is more difficult than the study of normal variation and progress is consequently slower.

SCIENCE AND POETRY

By Dr. CHARLES W. SUPER
ATHENS, OHIO

IN the year 1910 there were published in the United States, in round numbers, 13,500 books. This was an increase of about 2,500 over the preceding year. The total for Great Britain was nearly 21,000 for the same biennium. The German output was over 31,000 volumes, the variation between the two years being small. But compared with 1900 these figures represent an increase of nearly 6,000 volumes. The total number of book publications now reaches about 150,000 volumes annually, although in some countries pamphlets are also reckoned as books. In 1910 there were issued in the United States and Great Britain nearly 5,000 volumes under the head of fiction, poetry and the drama, the latter country slightly exceeding the former. To these should be added many translations, cheap reprints of novels of a more or less standard character, and a large number of plays, mostly comedies that are performed in every village, town and city from one end of the land to the other. Besides, a great quantity of both prose and verse never appears in book form. One can hardly take up a popular periodical without finding in it some of each, while many contain little else. Furthermore, a great many articles and even books are so permeated and even vitiated by the personality of the author when professedly dealing with facts that they may properly be relegated to the domain of fancy. Their contents pass through the mind of the reader, leaving hardly more residuum than the smoke that goes up a chimney. We need also to remember that the enormous output of the religious press is largely occupied with questions of a more or less theological character as distinguished from practical christianity, and is so colored with the views of the writers that it may be classed under the head of imaginative literature. We may make the same statement of almost all history dealing with periods more remote than two or three centuries. Hardly any two writers agree as to the reliance that should be placed on the so-called original documents; and there is no way of deciding the points at issue. Even subjects of a strictly scientific character appear to need the touch of the magic wand of the writer endowed with a vivid imagination to make them popular. In this kind of literature the French occupy the foremost place. Such books as Macé's "History of a Mouthful of Bread," Verne's fantastic stories, Figuier's "World before the Deluge," and others, have been translated into almost all modern languages and sold in great numbers. When we take into account this enormous mass of printed matter, to

which should be added the newspapers; and consider further that many of the metropolitan dailies contain enough words to make three hundred large volumes every year, we are constrained to believe that the present generation is one of readers, not of thinkers. We are in fact told now and then that thinking has almost become a lost art. In science a concept is recognized as produced by an external entity, or at least by an entity external to the cognitive faculty, as when it takes cognizance of its own operations and states. These concepts are verifiable by any number of experiments and observations and must agree in the main. Science deals with things that can be counted, or weighed, or measured. In poetry, speaking by and large, concepts are also recognized as external entities, it is true, but there is no agreement between any two observers and the phenomena are not verifiable. In truth, in all primitive poetry phenomena are envisaged as external, because the mind, though aware of its own operations, is unconscious of them. An important element of poetry is mythology, and mythologies are not the exclusive possession of primitive peoples. In the Homeric poems all mental states are regarded as external objects. We find the same conditions in the Old Testament. God is represented as speaking to men out of a corporeal body, or in dreams. This is just what we find in early Greek poetry. We can not draw a clear line of demarcation between the figments of the imagination and facts any more than we can do so between light and darkness. The imagination frequently leads to wholly diverse interpretations of the same data, as may often be seen in history. Here science finds its most difficult field of operations. What is called the historic imagination differs widely in different writers. Variety or lack of uniformity is a prime characteristic of all poetry. No productions on the same theme are exactly alike. In science there is a substantial agreement among any number of persons. The same feeling or emotion finds expression in many different ways. What an endless variety of treatment there is of the familiar theme of romantic love! It may be, however, that the passion does not manifest itself in exactly the same way in any two persons. This may seem a strong statement, but it is neither extravagant nor exaggerated in view of the circumstance that of all the millions of human beings upon the earth no two are so much alike that it is impossible to distinguish one from the other. The imagination often casts a glamor over persons of the opposite sex and endows them with attributes which they by no means possess. This state of mind is amusingly exhibited by Don Quixote with his rhapsodies over Dulcinea del Toboso, although she was in fact nothing more than a plain and coarse village wench. Similar instances occur not only in fiction, but even in greater abundance in real life. Here lies the limitless domain in which writers of imaginative literature find most of their themes. The Germans call both prose and fiction *Dichtung,* very properly making no distinction between the two since in both the imagination is the dominant agency.

When the imagination is kept within bounds by the intellect it discovers many general truths. Even our senses are constantly deceiving us when uncontrolled by the judgment. This control is lacking in the insane and in brutes. A horse that shies at a piece of paper blown across its path is doubtless influenced by its imagination. Its primal instinct is self-preservation and the unusual object portends danger. An unaccustomed noise or smell often produces the same effect.

Fiction, including poetry, is generally the production of a kind of unsystematic meditation in which successive steps are not logically correlated. These steps are the result of association, or suggestion and reintegration. If they follow each other in strictly logical order they could exhibit but little variety, perhaps none at all. Often a word or an idea brings into the mind another idea or concept that has a merely accidental connection with it. The process can not be foreseen because it is not alike in any two individuals. Neither can it be retraced or repeated, which may always be done when a chain of reasoning is strictly scientific. It usually has no very definite purpose and is rarely based on definite knowledge. In fact, definite knowledge usually dissipates a state of mind that does not differ widely from delusion. "Poetry," says Wordsworth, "is emotion recollected in tranquility." The scientist always regards emotion as a disturbing factor. It prevents his seeing objects as they are. Emotion interferes with clearness of vision and distinctness of mental apprehension. It is wont to endow objects with qualities which they do not possess. There is a vast difference between a slight possession and a deep-seated and ineradicable prejudice; but every step from one toward the other, no matter how short, is a movement away from the truth. Most men are more emotional in early life than in later years because experience and reflection enable, and often constrain them, to see persons and things more nearly as they are. An emotional state of mind in its intenser form is usually called enthusiasm. Carlyle employs a semi-German word, *Swarmery,* as being more expressive. Under the influence of strong emotion almost every person becomes an enthusiast. But it is only men of genius who can produce this mental condition at will. Few persons can remain in the emotional state of mind for a long time because the commonplace affairs of the world demand frequent returns to the normal state. On the other hand, there are persons whose hopes and anticipations so persistently deceive them as to unfit them for the stern realities of this world. It is difficult even for genius to deal with conditions objectively, to envisage phenomena with the clear apprehension that its own personality is a disturbing factor. In persons endowed with a literary mentality there is developed the style of an author, that is, his individual mode of presenting his thoughts to the reader. Every author of note exhibits this characteristic. Hence it is generally possible for experts to divine the authorship of

anonymous literary works. The late James T. Fields recognized some of De Quincey's unsigned essays which he found in periodicals; and although their author at first declared he was mistaken finally admitted what he had himself forgotten. Great as were the intellectual endowments of Byron and Goethe, commentators on their works profess to be able to discern their personality in everything that emanated from their pens. They were unable to get away from themselves. They viewed the external world through a medium which they could not lay aside. It is interesting to note the improvement in the esthetic taste the human psyche gradually underwent after men began to reflect upon their mental processes, although this improvement was doubtless at first unconscious. Homer describes minutely the harnessing of mules to a cart and the killing of animals for sacrifice. Furthermore, he exhibits a veritably diabolical ingenuity in devising ways by which men might be mutilated and slain. When their passions were aroused the historical Greeks were bloodthirsty to a degree. They sometimes put to death by thousands their prisoners taken in war. The political factions showed no more mercy than do those in some of the Central American states. Their judicial tribunals were often frightfully unjust. But when they calmly looked upon a tragedy they did not want to see any one openly slain. The Æneid of Virgil, though largely patterned after Homer, is pervaded by a much more humane spirit than the Iliad or the Odyssey. Yet the same Romans who read it with delight found pleasure in witnessing the gladiatorial games in which men and beasts lacerated and killed each other for the delectation of the spectators. During the middle age and far into modern times when religious persecution claimed its wretched victims by squadrons, the execution of human beings was often accompanied by the most frightful atrocities amid the applause or the silent approval of the spectators. But the modern novelist or poet who deals with these gruesome ages passes lightly over the more revolting incidents and permits the imagination of the reader to supply what he darkly hints at. Victor Hugo describes in minute detail, largely from his imagination, the slaughter of men and horses in the "hollow way" at the battle of Waterloo. But he casts a sort of halo of glory over victims and vanquished alike by extolling their bravery, their devotion to duty, their disregard of wounds and death, in order that he may arouse in the minds of his readers a sort of enthusiasm which makes him forget the horrors of the scene. The modern novelist is usually careful to eliminate everything from his production that would offend the esthetic taste, even to the extent of perverting well-established historical facts. "Egmont" is one of Goethe's most popular dramas; but its hero and the Egmont of history are totally different persons. The same may be said of Schiller's "Tell," by most persons regarded as attaining the highest excellence in German tragedy. Many of the eighteenth-century

novels are now but little read by reason of their coarseness, while such a simple story as the "Vicar of Wakefield" is as popular as ever. While, therefore, the general progress of events did much to humanize men, the movement was very slow, with many and long periods of stagnation, between about 400 B.C. and A.D. 1800. Persons of insight had learned to be humane before science had taught them the wisdom of humaneness. Science had made considerable progress before the latter date. But it was aristocratic. The common people concerned themselves little about it because it taught them almost nothing which it was to their interest to know. It dealt chiefly with large problems, not with the minute affairs of daily life. The fundamental difference between science and poetry is that the former seeks to know and to set forth the truth no matter what the consequences; the latter seeks to give pleasure. Coleridge says:

> Poetry is not the proper antithesis to prose, but to science. Poetry is opposed to science, prose to meter. The proper and immediate object of science is the acquirement or communication of truth; the proper and immediate object of poetry is the communication of pleasure.

Hence the poetic justice that plays so important a part on the modern novel is not the justice that prevails among men. Science brings before us the stern facts of the world in which we live, painful though they may be. On the other hand, imaginative literature either ignores those facts that pain the reader or weakens their effect by contrasting them with man's nobler traits or with human nature in "her calmer moods." Often a disagreeable subject is placed at a distance from us in either time or space. The Homeric poems are full of strife and slaughter and bloodshed and treachery; but they also portray conjugal and parental affection, valor, friendships that are not broken by death, piety toward the dead, fortitude and heroism. A novel in which all the characters are bad would be read by nobody. The popularity of Scott and Dickens is due mainly to the humanitarian spirit which their works display. They portray villains of the blackest type, but they always meet with the reward which we feel to be their due. Such novels are, therefore, not true to nature. Many knaves live to enjoy the fruits of their villainy to the end of a long life and die in peace. To the scientist nature is "red in tooth and claw"; to the poet she is a benignant mother, a provider of pleasure and a beneficent friend. A truth is often clad in a poetic garb. It then becomes a winged word, and impresses itself more firmly on the mind. It is poetry as well as truth. When Burns wrote: "O wad some power the giftie gie us," he put on a homely truth a poetic garment. On the other hand, the commonplace and unadorned dictum: "Honesty is the best policy," together with a thousand similar proverbs lacks every element of poetry. It is the embodiment of human experience, a sort of summing up of what men have learned in their

intercourse with one another. It is science. Proverbs are the small blossoms on the large tree of human experience. There exist odes to the skylark in every language spoken where this bird is known. No two of them are alike. But all descriptions of the skylark by ornithologists agree in the main. Carlyle often expressed disgust for "silly poetry." Yet he generally dealt with the facts or the reputed facts of history from such a strikingly individual point of view that a great deal of what he wrote belongs to the realm of the imagination as much as to the domain of history. He could not get away from himself,—probably did not want to. "Romola" or "Jane Eyre" deals with types and not with individuals. Their authors probably had some one in view for almost every character they introduced. But they are disguised. On the other hand, some of Carlyle's heroes are historical characters and bear well-known names. Nevertheless, they are almost as much unlike the familiar men and women of the ordinary text-book as if they belonged to the realm of fiction. The type never exists in unadulterated form. Very few every-day people are interesting. Consequently, when novelists bring them before their readers they exaggerate both their virtues and their vices in order to make them attractive. Dickens has a great deal to say about schoolmasters and schools. It is nevertheless much to be doubted whether the men and women he describes and the conditions as he represents them existed anywhere in England. By taking here and there from this person and that a trait or a personal peculiarity that best suited his purpose he makes composite portraits and portrays characters with such verisimilitude that we forget that they are largely the creations of his imagination. Albeit, the imagination is a wonderful and mysterious faculty. The orator is to some extent an artificial product; the poet is born. Unlike the intellect and the will, the imagination can not be trained. Dickens was almost without education; yet he portrays in his works fifteen hundred and fifty characters with more or less fulness of detail, while the number of names of places, societies, literary works, familiar persons and signs exceed two hundred. Balzac's works contains two thousand biographies, individual, distinct and, for the most part, complete. He usually takes each person at his birth and does not lose sight of him until his death. He also knows what the spirit of the country was in their time, the condition of the provinces and the trade to which the man belonged. He even knows what his income is, what taxes he paid, and the state of his culture. Yet Balzac's productive years hardly exceeded a score and Dickens died before reaching old age. In rare cases, but probably in more than is generally known, the poet and the scientist are combined in the same person. The Rev. C. L. Dodgson was a mathematician of considerable ability and expected his fame to rest on what he had done in this department of knowledge. Now hardly anybody cares for his mathe-

matical writings while there are few who do not find "Alice in Wonderland" exceedingly interesting. The little volume is so "excruciatingly silly," that we laugh over its absurdities without knowing why. Goethe was probably the only poet of modern times whose fame is world-wide and whose work in science was of a high order. But as science is progressive many of his ideas have become a part of its history and may be said to be outgrown. Moreover, as the world can not or does not believe that a man can be great in more than one or two departments, Goethe is known as a man of science only to specialists. Then too the interest in facts is confined to few, while fiction is attractive to the great mass of mankind. The late Professor Shaler was a man of similar type. He ranked high as a scientist and wrote dramas that contain many notable passages. But this sphere of his mental activity is not generally known. It is probable that no man engaged in research and investigation is a scientist "all through." Benjamin Franklin is an interesting case. From his earliest youth he seems to have had his mind almost exclusively on practical matters. Albeit, under the influence of Whitefield's fervent appeals he emptied his purse into the contribution box in spite of his first resolution to give nothing, then to give at least very little.

Many persons seem to be unable to distinguish at all times between the products of the imagination and concepts based on observed phenomena. Sir Isaac Newton is regarded as the founder of mathematical physics and physical astronomy. We are astounded at his marvelous intellectual acumen when we consider the inadequate instruments with which he had to work. Yet he devoted much time to theological speculation and wrote many pages that are mere puerilities. So feeble are they that M. Biot professed to believe that they were the productions of his dotage. But he was mistaken. Newton also spent a good deal of time on the writings of the alchemists and tried to discover the philosopher's tincture. There was evidently a large measure of the mystic in him. There was a good deal of similarity between his mind and that of Swedenborg. In many things the latter was thoroughly practical and a master of much useful information; but his mystical vagaries often led him far astray. To such an extent did Kant find this to be the case that he characterized him as the prince of visionaries. Sometimes men adhere to a creed adopted in early life and refuse to modify it no matter how much new evidence is brought to their attention. It is usually easier to defend an accepted belief because we have the materials ready to hand than to test the data which might lead to its abandonment.

Charles Darwin relates, in his autobiography, that up to his thirtieth year he was very fond of poetry, and even as a schoolboy took great delight in Shakespeare. But in his later years he could not endure to read a line of poetry, and on attempting to reread Shakespeare's plays

found them insufferably dull. On the other hand, he experienced great delight in reading novels, or in having them read to him, if they did not end unhappily, "against which a law should be passed." Many scientists, however, have held a different attitude toward poetry. J. S. Mill, although not a scientist in the strict meaning of the term, possessed a severely logical mind. When his premises were correct his conclusions have rarely been called in question. In his autobiography he says, when speaking of Wordsworth:

> What made his poems a medicine for my state of mind was that they expressed not mere outward beauty, but states of feeling and thought colored by feeling, under the excitement of beauty. I needed to be made to feel that there was real permanent happiness in tranquil contemplation. Wordsworth taught me this, not only without turning away from, but with greatly increased interest in the common feelings and common destiny of human beings.

Quite as remarkable both for what it was as for what it was not was the mind of William E. Gladstone. He is said to have been the only English statesman who could make a speech in Parliament two or three hours long crammed with statistics and bristling with figures yet hold the attention of his auditors to the end. Some of his contributions to the history of ancient Greece are considered to be of lasting value. On the other hand, in his controversies with Huxley and in his theological writings generally he displays such short-sightedness and such an obliquity of intellectual vision that the reader is sometimes prompted to ask himself whether Gladstone the statesman and Gladstone the theologian are the same person. Horace observed long ago that you might drive out nature by violent means, but it would always return. Although Darwin's mind seemed to be almost pure intellect, he was a man of kindly disposition, of strong feelings and wide sympathies. Many anecdotes are told of the ways by which his grandchildren tyrannized over him. Herbert Spencer was unable to suppress feelings of indignation when he witnessed an act of cruelty. He was powerless to explain this emotional state of mind and admitted that he could not help it. It is not putting the case too strong to say that every forward step in the march of human progress has been due to the constructive or creative imagination. In the man of routine it is very feeble, so feeble that it can hardly be said to exist. Columbus imagined the existence of a continent at some distance westward from the Atlantic coast as he knew it because he saw on the shores of Portugal branches of trees, two human corpses and other objects which he was convinced were not of European provenience. Many other persons had seen similar objects before him; but they did not set the imagination of the observers to work. In addition he had doubtless read the views of the Greeks as feebly reflected in a few Roman authors affirming that the earth is a sphere. Had his imagination been of the fanciful order he

might have written a poem or a novel the characters of which would have been the inhabitants of the western coast of the Atlantic. He might have given to the world a prototype of "Peter Wilkins," or of a "Journey round the Moon." If he had been on bad terms with everybody he would have produced an early version of "Gulliver's Travels," for which his experience with men would have doubtless furnished him much first-hand material.

The imagination performs an important service to mankind when it takes the form of sympathy. This is an emotion that scarcely exists among the lower animals. When some of the individuals of a flock of birds or a herd of beasts are injured or killed their companions pay no attention to them or take flight. The compassion shown by man for his fellow-man can not be explained solely on the ground of selfishness or self-interest. It exists where this motive can have no conscious influence. To be human and humane mean nearly the same thing. But the sympathetic emotion avails little unless directed by science. Those who are suffering from disease or injuries are not as much benefited by the active sympathy of a hundred ignorant persons as by the knowledge of one who knows how to alleviate their ills. The ravages of disease were not checked until science discovered their causes and preventives. It is one thing to bewail the sad lot of man, as has so often been done in both prose and verse, and quite a different matter to teach him how to better his condition.

The imagination performs an exceedingly important service in the sphere of human activity when it is called hope or expectation. Mark Akenside wrote an interesting poem on the "Pleasures of the Imagination" and Thomas Campbell a fine one on the "Pleasures of Hope," in which these emotions are dealt with from the standpoint of the poet. It must be admitted that they embody much of truth. The man who has no expectations and is no longer lured by hope has outlived his usefulness. There is little in the future that can be called certain, when it depends on human conduct. Action is usually conditioned by hope and the most vigorous action is inspired by the most ardent hope. But unless hope is enforced by a resolute will and guided by insight it rarely leads to tangible results. The alchemists were inspired by hope, but most of their labor was fruitless. The Spaniards sought the fountain of youth and El Dorado, but found only disappointment and suffering and death. Imaginative literature that keeps close to facts is a European product; and Europe has made more progress in a hundred years than Asia in a thousand. Nobody but a European would think of writing a "Treatise on the Creative Imagination." Nor would an Asiatic be interested in the pleasures of hope or of the imagination. The Chinese who have the reputation of being the most practical people in the world have made more progress in the last two decades under

the guidance of science than in the preceding two thousand without it. The imagination is the force that impels the scientist to seek new and hitherto unexplored regions in the vast domain of nature; but unless it is guided and controlled by the intellect it rarely leads to anything worth while.

Perhaps, however, the circumstance that our generation devours enormous quantities of fiction should not be taken as evidence that there is comparatively little thinking. Mental effort is largely expended along practical lines. Such problems as the existence of God, the priority of mind or matter, whether moral ideas are intuitional or evolutionary, metaphysical monism or dualism, together with a host of others on which philosophers were wont to expend their intellectual energies for more than two thousand years are now generally regarded as impossible of solution and are ignored. The world concerns itself little about transcendental questions and is turning with increasing interest to the consideration of matters that lie within its reach. Everybody now admits that the noumena of the cosmos are undiscoverable; the use to which the visible and tangible phenomena about us determines our moral and physical welfare and our mundane happiness as a whole.

THE RURAL OPPORTUNITY AND THE COUNTRY SCHOOL

By JOSEPH WOODBURY STROUT
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THE rural community is the granary of the world. Civilization is not possible without the farmer. The great city could not endure without the country. This feature of the economic situation is just now making itself prominent. The rapid increase of population in the cities naturally means decrease of population in the rural districts, which, in turn, means decrease in agricultural area, so that, while pro rata, increased products of the soil are demanded, decreased products are the facts. At least there is no marked increase of the food product of the world. These conditions bring the rural district to the front as holding the key to the situation.

But the rural community is not only the granary of the world, it is also the sanatorium of the world. In the fight against disease nothing counts for more than pure air, wild storms of wind, and isolation. This asset can not be measured in dollars and cents. Here also, the country becomes indispensable to the city. Hospitals and homes of all kinds, now, are pushing out into the country and gathering upon the hills. God's great out-of-doors is with the farmer, and medical science is making the largest possible use of it in that direction. The opportunity here opened for the rural community to fill a large place in the world is wide and deep.

Still another and perhaps greater opening before the rural community is its possibility to reform the boys and girls, stray waifs from the city, that are now being colonized in the country. Massachusetts has about abandoned her larger institutions for homeless boys and girls for the purer atmosphere of the farm home. Children of such type can be better managed in the country where they are isolated than in an institution where a hundred or more are segregated. Besides, the farmer, usually in need of boys, seldom fails to greatly benefit these waifs, and sometimes makes good citizens of them. I can point to a number of instances where excellent results have been obtained, and boys on their way to the penitentiary, and girls to the reformatory, have been lifted to higher planes of moral energy, trained often to take the initiative in large activities, meanwhile making for themselves homes of comfort and love. The opportunity is before the rural district to lift a large part of the world to new life, and to give new energy to that part of the world which is left.

Above all, in the greater persistence of rural family life, the greater stability of the marriage tie, the consequently larger family, the rural community forms a surer foundation for the future than the city. Professor Carver, in his "Principles of Rural Economics," says:

> The rural family is a stable institution, whereas the city family has become a relatively unstable one. The divorce rate is much higher in the cities than in the country districts. The city family tends to die out through celibacy, sterility and various other agencies, whereas the rural family persists. The farms not only feed the cities with their material products, but they also furnish the cities with men and women.

All this is within the possibility of the country community; in many ways, has always been, and now is pressing for recognition as a noble opportunity, yet it is here that the community has most signally failed. Some things along this line naturally are to its credit, but they are few, and compared with its possibilities and opportunities, seem insignificant. The locality that might render the world such high service seems oblivious to the demand. Knocking at its door to-day, asking for food and shelter, for new vision and higher planes of physical and moral energy, stands a great age, while the men of the rural community remain unseeing, unbelieving, timid, indifferent, almost antagonistic. The rural district is greatly hampered with an inheritance of social customs that well nigh negative any new thought, or hope, or plan. Its circle of thought is narrow, its plane of energy is low, and it easily wearies of any reform. On the other hand, the city is awake with vital energy. In his "Energies of Men," the late Professor James says:

> City and country people illustrate the difference between men who are energizing on a high and a low plane of life. The rapid rate of living, the number of decisions in an hour, the many things to keep account of in a busy city man's or woman's life, seems monstrous to the country brother. A day in Chicago or New York fills him with terror. But settle him there, and in a year or two he will have caught the pulse beat. And he will have come to enjoy this tremendous life.

That is, he will have climbed to a higher plane of energy, and is now using more of his possible power, living more nearly his larger life than before, and is a stronger man. But if the man from the rural district, under the city stimulus, can rise to a high plane of energy, may he not also do that at home, in the midst of his native environment?

The rural community must rise to these higher planes of energy and cultivate its great waste opportunities. It must learn that on its new birth, in the last analysis, the world of men and women are mainly resting their hopes for the future, not only for comfort, but also for life itself. Furthermore, it must learn, that, not only in the line of food, or in the way of health and happiness and reform, is it a necessity of the world, but also, in the possibility that its farm homes, in simple and subtle ways, by healthy, natural processes, may develop within their own

narrow limits many a strong soul, many a great man. This community can take the unfortunate, morally and mentally bent boys and girls from the crushing life of the city, and, under the clearer skies of a simpler life, by injecting more of the time element into their education, make them into new and wholesome men and women. It can stimulate its own boys and girls to higher ideals and larger views of the world, and by arousing itself to this mission the community can not fail, in large measure, to recover its own lost grip on the wider world.

A great day for the rural district is clearly at the front. Are the people of these localities awake to the opportunity? It is because I think I can answer the question in the affirmative that I am writing this article. But, given the appreciation that a great opportunity is at their door, the next movement is to grapple with it, and master it. That such may be done, the people will be compelled to make some marked changes in their thinking, and in their method of work. Here strong and wise leadership is called for. After the minister, no man has more nearly in his own hands the uplift of the rural district than the schoolmaster. The school is a power plant for intelligence, vision, training, and manhood. It is for use. And wisely used must render great help in solving the rural problem. But the school board, and the schoolmaster of the country districts, must rise to a higher and more intelligent plane of energy if they are to count in the new life of the community.

Our age may well be termed a renaissance. But in that character it has only just begun to dawn on the small and scattered sections of the country. There came a day in the fifteenth century when Italy renewed her youth. A new and mighty impulse to nobler ideals stirred the nation. Slumbering instincts aroused themselves, and songs of the spirit, unsung since the ancient empire passed away, became once more a joy and a glory. New songs were sung. The imagination reasserted itself, and the mind recognized a deeper and diviner significance in life. It is called the Italian renaissance, the rebirth of literature and learning and art in Italy. This awakening placed the nation on a high level of intellectual and spiritual energy where she soon demonstrated to the world that, in herself, she possessed an age, greater, in some respects, than that of Pericles.

But the rebirth of Italy was no miracle. It did not come in a night. It was largely the product of the schoolmasters. At least it involved the elements of learning and scholarship. The stimulus indeed was from without, being the discovery and possession of Greek literature and art, but in reality, the secret of it was in the stored energies of the people. It was the uprising of long dormant forces in the heart of a great nation. A miracle is not demanded to bring new visions and new energies to the rural community. It is only necessary that they hear

their call, and realize the need of developing their own deepest life. And in this it is only needed that they begin low enough and gradually rise to the mastery of their mission. In this the schools are indispensable. But to do its legitimate work the school must be manned with teachers who feel a divine call to service. That, in turn, calls for a school board with imagination and vision. Here the dearth is deep. The rural school is in poor condition to render much service, while the service demanded is great. The task of the teacher is to open new visions, to arouse deeper energies in the pupils, and through them to lift the ideals of the community, and to make the people hear the call of the times. The men must be shown how much possible energy, of a high order, right within their own district limits, is lost to the community and to the world because the boys and girls are not made to realize the value of more and better training, or kept in school long enough to find themselves.

This school is suffering sadly from social heredity. Thirty years ago I taught the winter school in a rural district down by the sea. It was in the proverbial red schoolhouse, in the center of the district, being a mile from the nearest inhabitant, in a grove of spruces through which the sunlight, save in little streams and eddies, never came, and directly opposite the village burying ground. A gloomier spot, or one less fit for a schoolhouse, it would be difficult to imagine. At the opening there were sixty-five pupils, ranging in ages from four years up to twenty-five. There were about as many classes, from the infant class learning their letters to the big boys studying navigation. The work went on according to the old customs and therefore was voted right. It could not have been very efficient. Three years ago I visited that school again. The schoolhouse, still red, stood in the old grove of spruces, sunless and damp, still fronted the north pole, the graveyard was still across the road, and not yet any sign of playground in sight. Some things had changed. They were having three terms of school instead of two, and all were taught by a woman. The pupils would not average as old as mine, emphasizing the growing tendency to drop out early, and there was no real attempt at grading, least of all any effort to put the school on a basis where it could better serve its own peculiar community. The lads, who, through the season, hauled lobster traps and seined mackerel, or cut stone in the great island quarries, were learning nothing about the sea, or the fish, or the stone formation of the island, albeit many of them had already chosen one of those lines of work for a life calling. The old class in navigation had dropped out. Twenty-seven years had marked few changes and no real advance.

And this is not an extreme case, either. Quite every rural school is failing in plan and purpose to exploit the vital needs of the community. I have examined a great many rural schools, making careful note of the

text-books they used. These books, in general, are quite in a foreign tongue. They possess literary value enough; the arithmetics contain an abundance of problems for training in railroading, manufacturing, brokerage, banking, insurance, the grocery business, what not, but only now and then an example on surveying, or measuring wood, and nothing whatever on mechanics and agriculture. The vocabulary contains some words that are in use in the district, but not the terminology in which the community is thinking and exploiting its hopes and fears, its ambitions and ideals, especially its practical life.

A light-keeper on one of the Maine islands, years ago, as I landed from a lobster smack to teach the winter school, said to me: "I am glad to see somebody who can talk something besides lobsters and mackerel." This island was engaged in those industries, and had one of the largest fleets along the shore, and was becoming a prosperous community. Naturally they talked "mackerel." In the schools, however, mackerel and lobsters were tabooed. They used the common text-books, containing about everything except what nine tenths of the pupils needed most to learn. I tried to obviate this omission by making problems directly related to their home industries, by teaching something about the resources of the ocean, the habits of its denizens, and kindred subjects, but to no purpose, for, immediately, I was overwhelmed with curt notes from irate mothers, saying: "We get enough talk about 'mackerel and lobsters' at home, without having it taken into the schools. Our men talk 'mackerel' all day and half the night, and we can't stand it to have the children take it up." Yet I had taken up the theme in a very different way, trying to cast about it enough of science and romance to take away the odors of familiarity, but they would have none of it. Fathers said to their boys: "Don't follow the sea. Its a dog's life." Mothers taught their girls to seek life in the larger towns and cities. Anything but the life by which they were winning their bread. They discouraged the hope of finding a larger life in their island wealth and the resources of the surrounding sea, and sent their boys and girls to the city.

The rural communities hitherto failing to row their weight in the economics of the world, now finding themselves dropping astern, are entering complaint of unfair treatment in the social and industrial distribution. This however may be a hopeful sign, for men are thus compelled to turn their attention to the conditions underlying the situation. In such an examination they can not fail to discover that there is great waste in these country districts, not only of land, but more striking and important, great waste of human energy. The girls and boys are not educated. The rural community has never made a just estimate of human values. Its values are in land and cattle, boys and girls are a kind of necessary nuisance. At the most, after twelve or fourteen years of age, they are left to train themselves. The community has never been

willing to finance the chances of these boys and girls by manning the schools with teachers of large enough caliber to hold them through the eighth grade, or to develop the possibilities of their lives for strong and useful careers. If such communities are ever to assume their normal burden in economics, or the social life of the world, their boys and girls must be carefully trained in the schools.

These communities have not only lost their best men to the city, but they have never tried to make the most of those who remained at home. Here is the opening for the schoolmaster. He must gather up the waste material in the persons of boys and girls, and by enriching and prolonging the course of study, hold them in the schools until they have obtained something like a fair knowledge of the elementary necessities of a life work. Now, the larger number of rural boys and girls leave school at the end of the sixth or seventh grade. If a boy hangs on a little longer it is because his parents force him to, and it is often at the expense of his self-respect, for he must go on with younger pupils. He is now twelve, or thirteen years old, and feels that, although staying in school, he is not getting anywhere, while he might be at work earning money.

After the seventh grade the rural school is well-nigh chaotic. It is pretended, by some school boards, that the full eight or nine grades are taught, but the wholesale manner in which pupils from these schools are turned down in the tests for the city high schools rather negatives the claim. The following figures taken from the government school report for 1903 are eloquent with misgivings. After the seventh, for the whole country, 20 per cent. of the grade drop out of school. But in the rural districts, where the seventh grade virtually finishes the course of study, the number dropping out is over 50 per cent. of the grade, which not seldom means all of the boys. The girls linger a little longer. Here is a waste of energy, a loss of vital possibility for which any amount of money saved can not compensate. Boys leaving school at such stage have not obtained the elements of a common education.

Still the country school has possibilities. Raised to a normal standard, generously equipped, and strongly manned, it can do much to redeem the waste and apathetic life of the community. It possesses the initiative of a renaissance, but it must be made the most of. In order to accomplish such result a great many customs must be readjusted to a new day and its larger environment. In this readjustment we must be sure and begin low enough, by giving thought to what hitherto has seemed insignificant, namely, the careful location of the schoolhouse, and its orientation. The school building should be in a dry, sunny, sightly spot. Ordinarily it should face the southern compass. This would move seven tenths of our rural schoolhouses, and turn more than half of them end for end. It is not at all necessary that a

school building should face the road, or be very near it. Light, warmth, horizon, room to play, these are the important considerations in locating a schoolhouse. Play, in the rural districts, is almost a forgotten art. No provision is ever made for it. No ball grounds, or tennis courts, or croquet lawns, are ever seen near the rural schoolhouse. The boys get no training in team work, or athletics. The community has yet to learn that a boy's play is a vital element in his education. Here, in the location and layout of the school grounds, is the first use of the rural school for community uplift.

Moreover the curriculum of the rural school is faulty. It has been kept at odds with its environment. In the midst of trees and flowers, birds and bugs, the child has been held down to a study of words and forms, and figures, not much related to his common life, and at the best too abstract for him to digest. He learns nothing of agriculture, mechanics, or biology. The children are not taught to study nature, or, in the least, directed or instructed in their play, except in a few instances. Nothing of manual training, even in simple forms, is ever attempted. These things have been crowded out by the old-fashioned literary curriculum. While there need be no neglect of reading, writing, spelling, or arithmetic, still, it is true that "these ought ye to have done and not to have left the others undone." Indeed, I would add to the reading and writing, together with the elements of agriculture and nature study, a systematic culture of memory selections, little enough of which have I found in any school. But it calls for a teacher of culture and training to make and exploit such a curriculum. Here the teacher is of paramount importance.

The teacher must be capable of leadership in the community. For, although these pupils may be learning only the elements, they must still be shown, at the right time, the wider world, in unison with which, when at their best, they also are moving. There must be opened to them a world of deeper significance than that commonly seen. They must be taught to feel the throb of a universe in the pulse beat of their own hearts. They must be filled with enthusiasm for life. This calls for a teacher of large caliber, of rich culture. It is a blunder, as well as a waste of money, to select teachers for the rural schools, as is now largely the custom, from the graduates of the high school. No one ought to be employed to teach a country school who is not a graduate of college, or trained in the best normal schools, or one who, by industry and experience, has gained an equivalent for such culture.

Then, after the seventh grade, the schools would become much more effective if they were centralized. The old district system has not lost all of its value, for the first six grades, or perhaps seven, can be taught in the old schoolhouse, providing that schoolhouse be rightly orientated and equipped with playgrounds, and other necessities, quite

as well as in the center, and the children are within their mothers' reach. But the next upper grades, in the rural community, must be centralized, strongly manned, with an adequate curriculum. Here manual training and elementary agriculture, can be taken in hand, and when this is done in earnest and with skill and enthusiasm, it becomes interesting, and by its appeal to the boy's larger self, holds him longer in school.

But the rural district needs a high school. It may be true that no rural community can equip a school that would compare with the city high school, where, now, some of the boys and girls are sent; nevertheless if it would take its own place in the world, the rural community must have its own high school. For it is not the boys and girls that are fitting for college, financed and forced by their parents, who create the school problem here, but the boys and girls who have not so much as heard that there is a college. It is the large number of pupils that might attend high school, and possibly go up to college, were a high school nearer home involving little, or no expense, and for which, to some degree, their fathers were responsible, who complicate the school problem, and make it vital. No one can conjecture what talent, or slumbering genius even a year in the high school might develop in the dullest boy. And it is the possible boy and man who must be provided for. The waste of possible men and women of greater parts than the common life bears witness to among the farmers is great and sad. In the face of so much latent energy of the highest kind, the talk one hears about the expense of the thing is utterly unworthy of an intelligent community. It is indeed true that the farmer has suffered from the tax system of our government more than any other class, but it is not so much demanded that more money shall be raised, as that what is raised be more intelligently expended; so placed that it can make returns in character and in life.

Now that the world, once more, is waking up to the fact that the rural community is an absolute necessity in the economy of civilization, a splendid opportunity opens before the schoolmaster to make himself felt. Here the schoolhouse may become the power house of a higher life. But the master must have the training necessary to reach the practical element in these problems; he must be able to meet the boy's need of a dignified curriculum, and he must possess in himself a never-ending fund of imagination, of enthusiasm, and of long vision. Given such a man backed by a well-equipped schoolroom, and the community has a powerful asset towards grappling with the new life of the day, and meeting the economic, political and moral demands now being made upon it.

EARLY GEOLOGICAL WORK OF THOMAS NUTTALL

By Dr. CHARLES KEYES
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WHEN, in England about a century ago, earth-study was made a modern science through William Smith's famous geological discoveries that the relative age and natural sequence of rock-layers were susceptible of accurate determination by means of the contained organic remains, America very early, and from a wholly unexpected quarter, furnished important aid in support of the newly established principles. The circumstances were long since all but forgotten. In the few casual references made to them in latter years either their significance was misunderstood or familiarity with the attendant conditions was entirely wanting. As the first successful application of modern geologic principles in the New World the episode must ever remain of greatest historic interest.

Singularly, this primal American effort to correlate by their faunal contents geologic formation widely separated geographically was not made in that portion of our continent which was most accessible and where it was most natural to expect it—that is, along the well-settled Atlantic border—but it was in the then remotest section of the upper Mississippi valley. First fruits of research and observation were obtained in a region which was then perfect wilderness, but which now forms part of the great and populous state of Iowa. Moreover, these remarkable observations were made within a decade of the time when the novel method was originally announced in England. They antedated by fifteen years Samuel Morton's similar effort on the Tertiaries of our Atlantic coast commonly regarded as the maiden attempt in America along these lines. By two decades they were in advance of the first work of that pioneer American paleontologist, Lardner Vanuxem. They anticipated by a full generation the famous investigations of Thomas Conrad and James Hall in New York. Indeed, they were the means of actually and correctly interpreting the true position and biotic relations of the Carbonic rocks of the continental interior a half century before their geologic age was otherwise generally admitted. The Mississippian limestones, as the rocks are now called, remain to-day as compact and as sharply delimited a sequence of geologic terranes as they appeared when first recognized in that memorable summer of the year 1809.

This successful use in America of faunal criteria for purposes of solving problems of geologic correlation and of identifying geological formations was the first real ray of modern light to penetrate the strati-

graphic darkness shrouding the New World. The happy application of these criteria was due directly to the keen scientific perception and peculiar reasoning of one who was never known as a geologist at all, but who was raised to fame through a wholly different channel of scientific activity. The name of this truly remarkable personage was Thomas Nuttall, botanist.

Nuttall's extensive travels in America were undertaken chiefly in the interests of his monumental works on North American plants and of his valuable contributions to American ornithology. On his first great trip, after traversing the southern shore of Lake Erie, and coasting by canoe Lakes Huron and Michigan, he entered Green bay, and, following that famous all-water route to the west which the Indians had used from time immemorial, ascended Fox river to the short portage to the Wisconsin river, down which latter stream he floated to its mouth, near Prairie du Chien, thence down the Mississippi river to St. Louis. Subsequent trips took him far up the Missouri and Arkansas rivers.

On his Mississippi venture besides garnering great quantities of interesting plants and taking voluminous notes on the birds, he appears to have made extensive collections of the fossils which he found throughout his path abundantly scattered through the limestones which in high cliffs bordered both sides of the great stream. In the course of his explanations of the geologic features of the region through which he passed Nuttall naïvely notes that he is "fully satisfied that almost every fossil shell figured and described in the 'Petrifacta Derbiensia' of Martin was to be found throughout the great calcareous platform of secondary rocks exposed in the eastern Mississippi valley." Thus by means of fossils he parallels these limestones of the Mississippi river with the mountain limestone of the Pennine range in Derbyshire, England, to which, several years later, Conybeare gave the title of Carboniferous.

Along the Mississippi river, as we now know, Nuttall really encountered little else than rocks of Early Carbonic age, so that his identifications of the fossils were doubtless, with very few exceptions, correct. Moreover, at this date and for some time afterward, the lower portion of the exposed stratigraphic sections, it must be remembered, was entirely undifferentiated, the great sequence of older beds which were subsequently separated from one another being jumbled together under the title of Transition group. It was not until more than a quarter of a century later that out of them, in Britain, Murchison and Sedgwick established the Cambrian, Silurian and Devonian systems.

Another important geologic correlation is to be credited to Nuttall. On his journey up the Missouri river, in 1810, which he undertook with John Bradbury, a Scotch naturalist, he reached the Mandan villages on the upper reaches of that stream. He makes especial mention of the

Omaha village situated below the mouth of the Big Sioux river. A short distance upstream from the last mentioned point he examined strata which, by means of their fossils presumably, he refers to the Chalk division of the Floetz, or Secondary, rocks of northern France and southern England. This is the earliest definite recognition of beds of Cretacic age in America. It preceded by a decade and a half the separation, by John Finch, of the newer Secondary rocks from the Tertiary section in the Atlantic states, and Lardner Vanuxem's and Samuel Morton's references of the same deposits to the Cretaceous age. Thus also was another great succession of one of our main geologic periods discovered in a then remote part of our continent years before it was recognized in the East.

At the mouth of the Big Sioux river Nuttall fell in with an old trapper who described to him the great falls which blocked navigation at a distance of 100 miles up that stream, and who told him of the famous Indian pipestone quarries beyond.

The analogy established by Nuttall between the general Carbonic section of Iowa and the upper Mississippi valley and that of northern England was one of the important geologic discoveries in America. Its great significance was pointed out by Owen a couple of decades later. Its historical value grows with the advancing years. In the final recognition of a standard Carbonic section for this continent the sequence displayed in the Mississippi basin must prevail, since it is now generally conceded that the Appalachian succession of strata can never be considered as the typical development.

So conspicuously botanical in character are Nuttall's services to science that one can but wonder under what circumstances he could have obtained his keen insight into matters geological. Elias Durand said of him immediately after his death that "No other explorer of the botany of North America has personally made more discoveries; no writer on American plants, except perhaps Asa Gray, has described more new genera and species." Lists of his published memoirs and papers quite generally omit all reference to his recorded geological observations, probably because their importance could hardly be fully appreciated by writers in other fields of science. In the present connection our main interest centers on the transplanting so early to the interior of the American continent of Williams Smith's novel ideas concerning fossils. Brief reference to some of the early events in Nuttall's life seem to offer a clue.

Nuttall was born in Yorkshire, England, in the mountain limestone belt, and near the scene of Martin's famous labors on the Carbonic fossils of Derbyshire. He was early apprenticed to the printer's trade and after a few years removed to London. There he followed his trade until, at the age of 22, he set out for America, in 1808. He appears to

have been a printer of the Benjamin Franklin order, since while engaged at his trade he became proficient in the knowledge of the sciences, Greek and Latin, and kindred subjects. During the period of six or seven years that he was in London he appears to have made the acquaintance of a number of the scientific men of the day. At least it is probable that at this time he acquired some familiarity with Smith's discoveries, which were at that date attracting wide attention from English scientists. It is also quite possible that Nuttall gained much of his scientific information through setting up the types for those very memoirs which have since become geologic classics. It is not unlikely also that he even met Smith, since the latter is known to have been often in London at that time, and to have taken up his permanent residence there several years before the printer-naturalist left his native country.

At any rate, Nuttall had been in America scarcely a year before he was putting his geological knowledge to test. His familiarity with Martin's "Petrifacta Derbiensia" and Smith's principles clearly indicates that he must certainly have acquired his information at least several years previous. Then, too, his acquaintance with that pioneer American geologist, William McClure, for twenty years president of the American Philosophical Society at this period, should not escape notice. Two other papers, partly geological in nature but chiefly mineralogical in character, on the rocks and minerals of Hoboken, and of Sparta, New Jersey, and the many keen observations on the rocks recorded in his journal of a trip from Philadelphia to Pittsburgh attest his unusual intimacy with matters in geology.

Notwithstanding the fact that the brief memoir which Thomas Nuttall published on Iowa-land and the contiguous regions was the only one which he seems ever to have printed on strictly geological subjects so important are the principles set forth for the first time in this single, simple, short contribution to the literature of American terranal correlation that it places its author in the front rank among pioneer geologists, not only of Iowa, but of our country. Although one of the foremost botanists of his day, and an ornithologist of world-wide reputation his great service in first pointing out by method and by means the fundamental concepts of modern historical geology in America should not be forgotten.

THE STRUGGLE FOR EQUALITY IN THE UNITED STATES.

III

By Professor CHARLES F. EMERICK
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Politics and Business

A common objection to political agitation is that it disturbs business, and either diminishes or renders uncertain the incomes of the laboring and property-owning classes. As an argument against agitation that is purely destructive, this objection is undoubtedly sound. To unsettle business without the prospect or possibility of sooner or later bettering working and living conditions is to render the existing situation worse and is therefore unjustifiable. But as an argument against agitation that is constructive the objection is footless. To urge people to submit tamely to things as they are is to argue that existing conditions are either as they ought to be or that they are incapable of being righted. Neither of these positions can be accepted. Moreover, to inculcate a fatalistic spirit would in the long run be bad for business itself. For the element in human nature that protests against injustice and contrives ways and means to overcome it is closely allied to the element that discovers defects in and improves the technique of industry. The fact that our age is not only highly inventive but also much given to social amelioration is more than a mere coincidence. Whatever lessens the latter is apt to deaden the former.

I

A favorite argument in certain quarters is that if the business world were let alone it would reform itself without suffering the disadvantages which political agitation entails. This position is untenable. In the first place, the business world can not if it would leave politics alone. Business enterprise dependent upon franchises and corporate privileges inevitably drifts into politics. Wherever matters of public as well as of private concern are involved, the state is necessarily a party to the transaction. This is notorious in the case of the liquor traffic. So long as business men embark in enterprises dependent upon a protective tariff, they can not well complain if they become the victims of political agitation. Those whose interests are opposed to protection quite as much as those who profit by it are entitled to a hearing. Many of the questions which arise in connection with money, banking, railways, trusts and the relations between capital and labor can only be settled by political action. In foreign relations the state is the handmaid of business. Business and politics simply can not be divorced.

In the second place, the diversity of opinion in the business world itself is mainly responsible for the prolonged controversies that unsettle business. In our political contests, the business interests are not a unit. They are not agreed about reforming the currency or revising the tariff. In regard to the trusts, the small capitalists are opposed to the large. In the controversy over railway rates, many farmers, manufacturers and shippers have been arrayed against the railways. At times the railways have entered politics to prevent the large shippers from securing rebates by playing off one road against another. The agitation which led to the enactment of the Elkins law in 1903 is a notable instance. There is no such solidarity of interests among business men as the socialist doctrine of the class struggle would lead one to expect. Our industrial leaders compete scarcely less in the political than in the industrial field. Some of them enter politics to obtain favors for themselves, while others are compelled to enter for self-protection. The railway interest has occasionally been on the offensive and then again on the defensive in our politics. Business men are less in the political limelight than lawyers, but they are more frequently the moving power behind the scenes. There are no more persistent political strategists than many members of the business community. Without their support, many a professional politician would find himself out of a job, and the political agitation that unsettles business would have a very short life.

In the third place, more important than reforming business is the problem of keeping it on a high level, much as the preservation of health transcends the curing of disease, and what preventive medicine is to the public health "pitiless publicity" is to the level of business morals. It is only in a political atmosphere that is potentially critical that those in charge of large business can be expected to be on their good behavior. If every would-be agitator were put under lock and key, the tone of business life would undoubtedly sink to a lower plane.

Fourthly, the fact that business, if let alone, will reform itself is no argument against the use of means that promise to hasten the process, any more than the fact that a patient will in time get well proves that there is no use in calling in a medical practitioner. The doctrine of laissez faire has long since been discredited.

Fifthly, the disturbing effect upon business of political agitation that is necessary should be sharply distinguished from that which is unnecessary, and due account taken of the fact that the self-seeking demagogue is by no means wholly to blame for the latter. The obstinate shortsightedness of not a few men prominent in the business world is also responsible. In place of cooperating with well-meaning politicians in devising appropriate remedies for manifest ills, a studied attempt is frequently made to arouse opposition by creating a state of alarm. To this end the mildest kind of proposals are misrepresented by a subsidized press, the most sinister motives imputed to their advocates, and the pos-

sible ills that may ensue grossly exaggerated. The consequence is that much-needed reforms are sometimes delayed and the temper of the public tried until the foundation of the business order is undermined. It is not far from the truth to assert that certain opponents of the "Roosevelt policies" unwittingly contributed more to bring about the panic of 1907 than did the utterances of Mr. Roosevelt himself. The movement for railway control has made headway in the face of the most pig-headed opposition. A good deal of the time of the conservative reformer is taken up with denying allegations which he has no thought of entertaining. Mr. Lincoln, in the course of one of his debates with Douglas, said:

> I protest, now and forever, against that counterfeit logic which presumes that because I did not want a negro woman for a slave, I do necessarily want her for a wife.[13]

The foresight with which men of affairs are commonly credited often fails them when it comes to dealing with public opinion. This appeared in the tactless manner in which the coal operators treated the public during the anthracite strike. According to *The Commercial and Financial Chronicle,* the New Haven management in the acquisition of trolley lines in no wise strengthened the system, but laid itself open to the charge of trying to establish a transportation monopoly.[14] The fact that the business magnate frequently turns out to be a poor strategist in his relations with the public is no occasion for surprise. Intent on furthering the particular interests with which he is entrusted, he is apt to lose sight of the public interest and to do things which end in bringing down upon him a storm of popular disapproval. Positions of command tend to beget an undue sense of power and a supercilious attitude in one's relations with his fellows. The masterful spirit is often overbearing. The head of a large railway, industrial combination or public service corporation in a large city should be enough of a statesman to understand what the public wants as well as what is good for the general welfare, and in a democracy the man who feels that he belongs to a superior class is unable to understand his fellow men and is incapacitated for this service.

Sixthly, political agitation that is sane and efficient makes for business stability, or at least any ill effects are temporary and are far outweighed by the good effects that abide. It is easy enough to understand why bankers and others who deal with such a sensitive thing as credit view anything that unsettles business with alarm, but there is less excuse for failure to see that the cause of unsettled business is not the agitation which issues out of grievances but the grievances themselves. Reform that is genuine and real is the foundation of enduring prosperity. So

[13] Debates of Lincoln and Douglas, *op. cit.*, p. 22.

[14] July 12, 1913, p. 86.

averse is an influential portion of the business world to change, that this point is frequently overlooked or but partially recognized.

Amicable relations between the railways and the shippers could not exist so long as unreasonable discriminations were practised by the former. In granting franchises, the public can not be expected to acquiesce unless its interests are properly safeguarded. The passage of the Allen bill by the Illinois legislature constituted a challenge to good citizenship, and there could be no peace until the objectionable bill was repealed. The painful working out of the franchise question in Chicago and Cleveland has placed the street railway securities of these cities on a sound and reputable basis. The report of the commission appointed by President Roosevelt has made for peace in the anthracite coal fields. Not until the tariff is rescued from the hands of special interests and is settled to the satisfaction of the country will the business community know upon what to count. So far as legislation is concerned, much political agitation is either fruitless or results in unwise action. Due credit should, however, be given to an important by-product, namely, the stimulating effect upon the correction of abuses by voluntary action.

II

Modern industry repeatedly adjusts itself to new conditions with surprising ease, and those in charge of any business are frequently the first to protest against a proposal to return to the old order of things. The packers advertise that their meats are "U. S. Government Inspected." Insurance companies doing business subject to the laws of such states as Massachusetts, Connecticut, New York and Wisconsin, proclaim the fact. The national banks find the supervision to which they are subjected a valuable asset. The investor's attention is called to the fact that an issue of securities has been approved by a public utility commission. Publicity of corporate accounts has proven a good thing for railway and other corporations. Factory managers now and then face about and approve regulations which they have opposed.[15] It often happens, also, that the arch insurgent of to-day is looked upon as the cautious-going conservative of to-morrow. The south no longer regards Lincoln as an enemy, but as a friend, and among the possibilities of the future is the spectacle of the business interests rallying around a La Follette as their defender against some form of radical-going socialism.

The need of distinguishing between the symptoms and the causes of political unrest is well illustrated by the silver agitation. No political movement since 1870 excited such bitter controversy or did so much to unsettle business. It undoubtedly occasioned the panic of 1893, and prolonged the hard times which followed. The legislation of 1878 and 1890 made our monetary system topheavy and rendered the continuance of the

[15] Hutchins and Harrison, "A History of Factory Legislation," second edition, p. 155.

gold standard doubtful. The principal cause of the panic, however, was *the appreciation of gold.* The persistent fall of prices increased the burden of debts and imposed an unmerited hardship upon large numbers of producers. The free coinage of silver was demanded as a measure of relief. The remarkable increase in the world's output of gold relieved the country from the menace of the silver movement. If prices had continued downward, if wheat had fallen to twenty-five cents per bushel, as Mr. Bryan wrongly predicted, the silver agitation would probably have continued unabated. Likewise, the discontent due to the present era of rising prices promises to continue until the cause is removed, or until the depreciation of gold is offset by some monetary device. Economists are at present discussing the practicability of a "compensating dollar."

Too much is made of the extent to which industry is occasionally disturbed by proposed reforms. Human nature is prone to make a scapegoat of others for failures which belong at home, and this tendency seldom appears in a poorer light than when some man of large affairs blames a leading politician for results due to his own cupidity, lack of judgment or dishonesty. If political discussion did not arouse the unwary and keep the investing public on its guard, there is no telling to what lengths the issue of fraudulent prospectuses, the excessive capitalization of good will, the merging of properties at fictitious valuations and other methods of high finance would be carried. Neither is it possible to foresee how much mutual confidence and good faith would be undermined and business disturbed if the politician did not stay the use of these methods. The ordinary man often owes the politician a vote of thanks for saving him from the wiles of the manipulator of securities. The dishonest promotor is less in the public eye than the dishonest politician and is therefore more of a menace to the community. The security market needs more, rather than less, political airing. There is too much parrot-like imitation in making investments, too strong a disposition to accept off-hand opinions as authoritative, too little proneness to analyze reports and to form independent judgments. The result is that the only dollar many people feel sure of is the one they have spent. A leading Chicago daily remarks editorially:

> Neither legislatures nor state commissions are responsible for the troubles of the New Haven system. Yet those who have complained and demanded investigation have been denounced as enemies of railroads and their security holders. What would happen if we had a vast twilight zone in the railroad world; what speculators, would-be monopolists, experts in the art of running railroads from Wall street would do in that zone may be left to the imagination of intelligent men.[16]

Modern industry is so organized that it alternates between excessive activity and stagnation, and if it were possible to divorce business from politics there is little reason to suppose that trade fluctuations would be less marked. On the contrary, the reverse would probably prove true.

[16] *The Record-Herald,* July 10, 1913.

One of the most salutary uses of political agitation is, by sounding a note of caution, to keep business from running to that excess from which it is sure to rebound. Even agitation that is purely destructive may serve this purpose, however harmful it may be in other ways. The complete cessation of political agitation among a people so self-confident as those of the United States would in all probability result in such a reign of speculative activity as to prove a calamity. The politician helps to keep the industrial ship from becoming topheavy.

The fact that political agitation brings out the social side of modern life goes far to compensate for any unwarranted interference by agitators with business affairs. The various facilities, such as schools, books and magazines, which quicken the popular intelligence, would exist to little purpose if the ethical relations in which the age is so rich were barred from discussion. But for politics, considerations of public policy and the equity of social and industrial relations would receive all too scant attention. Few things bring out better the fact that we are all members one of another, or do more to turn people aside from sordid and purely personal ends. There is no game in which the nation finds more delight than politics. Few matters are so frequently the subject of editorial comment or occupy more space in the newspapers and magazines.

Our recurring presidential campaigns have an educational value which the preferential primary by compelling rival candidates to make their appeals directly to the voters promises to enhance. The discussion of such questions as free silver, the tariff, conservation, and the regulation of trusts and railways stimulates the popular intelligence. Viewed simply as a schoolmaster, Mr. Bryan has for years rendered the country an invaluable service. The wisdom of electing state officers and both houses of a legislature every year, as in Massachusetts, is more than doubtful. It is a fair question, however, whether the gain in having our presidential elections come every six years in place of quadrennially is worth what would be lost educationally. The discussion of national issues helps to preserve our sense of nationality. The primary purpose of democracy is not that men may become rich, but that human nature may be perfected by discussion, deliberation and criticism, by exercising the power of self-control, and by learning to give due weight to the rights of others. Any civilization is to be judged by the way it reacts upon the moral and spiritual side of man, and not by the extent to which it heaps up riches, however necessary the latter may be to human wellbeing and progress.

III

In politics, as elsewhere, discretion is sometimes the better part of valor. The protected interests have mainly themselves to thank for the reduction of the tariff which they have experienced at the hands of the

Wilson administration. If they had acquiesced in a moderate reduction of duties in 1909, it is probable that they would have been spared the heavier reduction in 1913. If they had permitted the Payne bill to pass the Senate substantially as it passed the House, in place of amending it until it is doubtful whether it revised the tariff upward or downward, the country would probably have accepted the measure as a satisfactory settlement of the question. By overreaching themselves they incensed public opinion and invited a more thoroughgoing reduction of duties.

Among the arguments against protection is that it inevitably makes business the football of politics. When the tariff is under discussion, business usually slows down until the outcome is foreseen. The average tariff has a short life. Moreover, discussion that does not end in legislation often disturbs business as much as that which does. As a consequence, the protected industries seldom enjoy a long respite from the uncertainty which the discussion of the tariff necessarily entails. The history of the tariff since the Civil War, however, indicates that in the end the protected interests have usually come out on top. After the war, the internal revenue duties on many commodities of domestic production were either reduced or abolished without any corresponding reduction in the import duties. In other words, the margin of protection was substantially increased. The attempt to reduce duties in 1867 was unsuccessful. The reduction of ten per cent. in duties in 1872 was repealed in 1875. The act of 1883 lowered some duties and raised others, but it left the protective system substantially intact. Mr. Cleveland's famous message in 1887 urging a reduction of duties ended in the McKinley act raising duties to a new high level. The democratic tariff of 1894 reduced duties so slightly that Mr. Cleveland refused to sign it. In 1897, the McKinley duties were practically restored, and it is doubtful whether the act of 1909 made any reduction in the average level of duties that served a protective purpose. During all these years, moreover, besides the ad valorem duties that were avowedly protective, an additional amount of protection was concealed in specific duties that purported merely to compensate for the tariff on raw materials. As parliamentarians and political strategists, the protected interests have been more resourceful than their adversaries. The alliances between wool growers, woolen manufacturers and other interests have repeatedly carried the day. The tariff of 1913 marks practically the first discomfiture the advocates of protection have suffered since 1860.

But perhaps the discomfiture is more apparent than real. Taking the country over, the business interests have shown little concern over the reduction of duties. There has been less alarm than preceding the tariff of 1894. With the exception of a few industries, the volume of business has continued at a high level. The net earnings of many industries and of some railways have increased. Apparently, a high tariff

is no longer regarded as so vital a matter as twenty years ago. In many instances, only the duties that were nominally protective have been removed by the act of 1913. Two noteworthy exceptions are wool and sugar which go on the free list, the latter, however, not till May 1, 1916. The duties on silks were probably left well above the maximum revenue yielding point. There is no reason to suppose that barbed wire will sell for less because it has been placed on the free list. The new tariff will probably reduce the cost of living but little for the average family. The by-elections, thus far, indicate a vote of confidence in the administration. Moreover, the division of the opposition into Republicans and Progressives promises to give the new tariff a fair trial. It may turn out that the popular mind has exaggerated the importance of the tariff. Many have attributed the panic of 1893 to the tariff of the following year. The part played by the appreciation of gold, the silver agitation and the reckless expansions of railroads during the eighties has been frequently ignored. It has been common to explain good times in terms of a high tariff and hard times in terms of a low tariff. The building of railways has done far more for our industrial development than the tariff, and yet it is usually treated as a matter of minor importance in popular discussion. There is at least a chance that the country will revise its theory of prosperity. Certainly, an industrial policy that promotes the growth of cities is less needed than fifty years ago. The panic of 1907 helped to shatter the popular belief that a high tariff insures prosperity. Much will depend upon the character of the times during the next three or four years. If times are good, the lower duties will probably receive undue credit. If times are hard, an undue amount of blame will probably be laid at the door of the new tariff.

IV

The public mind is at present very suspicious of lobbyists. President Wilson recently promoted the progress of the tariff by calling attention to the number of lobbyists in Washington. The right of every one to present any facts, either in person or by proxy, to the members of our legislative bodies is generally conceded. The special interest is entitled to a hearing as well as the disinterested philanthropist. The protected manufacturer has the same right to be heard as the opponent of child labor. If the presentation is done in the open, and if the arguments employed are addressed to the minds and not to the pockets of our legislators and are unaccompanied with threats, no exception can well be taken. The average member of our legislative bodies, as well as the general public, can be trusted to make due allowance for anything one may say in behalf of his own interests. On the other hand, when those who present the facts possess the ballot, there is a fair chance that what they say will receive due consideration.

Why, then, are lobbyists regarded with such suspicion? The answer

is that legislative agents have not contented themselves with presentations of facts. They have brought improper influences to bear upon our legislative and executive officers. Perhaps the extent of such influences is exaggerated. The press is prone to chronicle the evil rather than the good that men do. Exceptional instances of wrongdoing may be mistaken for the rule rather than the exception. Lobbyists are, however, rightly regarded with suspicion. The sugar trust long since earned for itself a notorious reputation. In truly non-partisan fashion, it has helped out the campaign funds of Democrats and Republicans alike and has placed both parties under obligations to look after its interests. Its rebating, custom house frauds and secret tapping of the New York City water supply have added to its notoriety. Not many years ago a street railway magnate was reputed to own the city government of Chicago in much the same sense that a merchant owns his stock of goods. "The only reason we do not have a parcels post is the four express companies," John Wanamaker is said to have remarked, when Postmaster-General. The legislatures of certain states have occasionally been the adjuncts of railway or other corporations. The investigation of the insurance companies by the Armstrong committee, whose labors Mr. Hughes so ably directed, disclosed a startling condition of affairs. The venal legislator who introduces "strike bills" has intensified the general sense of suspicion. The excessive multiplication of briefless lawyers who find it difficult to make a living has doubtless contributed to this condition. Organized labor in common with organized capital has violated the proprieties of life. When a vote affecting the employees of the Boston Elevated was taken during the last session of the Massachusetts legislature, the employees in their uniforms, present in large numbers, made such a demonstration as to intimidate certain legislators. The insidious control of certain members of the press for sinister purposes has excited popular distrust. The newspaper dependent upon legal advertisements or upon any special interest for support is to that extent compromised as an organ of public opinion.

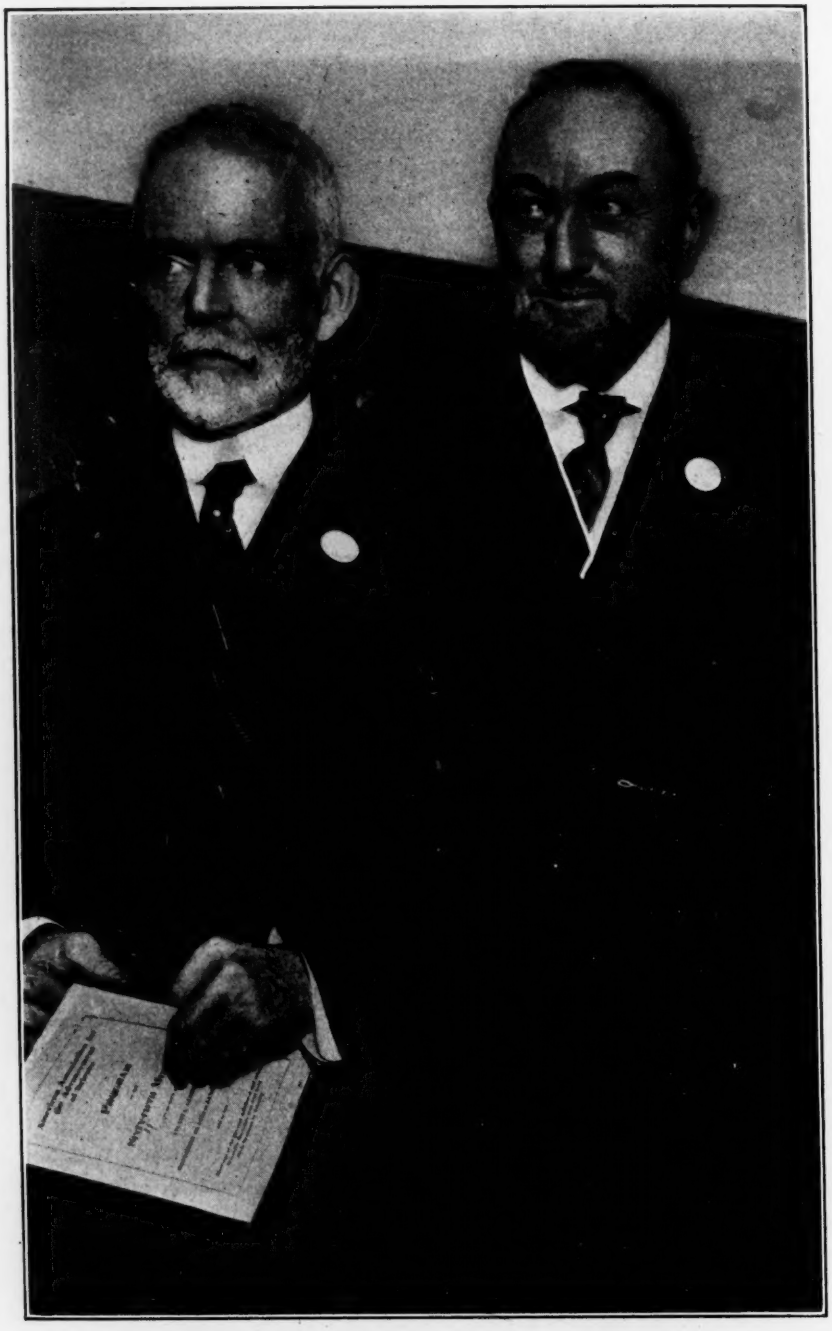
The indiscreet friends of a cause are frequently its worst foes. This is true of protection. There are arguments of weight which can be advanced in favor of a protective tariff. The young industry argument is entitled to respect. It may be wise to diversify industries even at considerable economic sacrifice. Self-preservation requires a nation to produce at least part of its military supplies. Not least among the advantages of protection have been its political consequences. By centering attention upon Washington, and by rendering the different portions of the country industrially interdependent, it has contributed to our unity as a people. Unfortunately, however, such considerations have frequently exercised little influence in the enactment of tariffs. Log-rolling has repeatedly extended protection to industries to which it should never have been accorded. Many industries have claimed pro-

tection solely as vested interests. Undoubtedly, when protection has once been applied to an industry, it should not be abruptly withdrawn. This is hardly a reason, however, for according protection in the first instance. When tariff bills have been under consideration, Washington has been literally besieged by lobbyists. Private ends rather than consideration for the public welfare lead men to overcrowd the hotel accommodations of the capitol. Presumably the expectations of selfish interests have in a measure been realized or they would long since have ceased to flock to Washington. Even the most ardent believer in "the economic harmonies" will hardly maintain that such a condition is consistent with the public weal. It is commonly believed that "campaign contributions" have been the price of a generous measure of protection. "Jokers" have found their way into tariff acts with alarming frequency. It is not surprising, therefore, that protection has suffered a partial eclipse. In fact, the most serious objection to protection is that it undermines the tone of public life. To meet this objection, its more discreet advocates have from time to time favored a tariff commission. A tariff commission has also been favored by some with a view to postponing or moderating a drastic cut in duties. The arguments which have done most to uphold protection have been in the main those of doubtful validity. The arguments entitled to respect have had little to do with its popularity. In spite of the frequency of tariff discussions, there are few subjects on which there is more loose thinking.

Three things have made the lobbyist a special menace to our public life. The first is government by committees which, according to James Bryce, "gives facilities for the exercise of underhand and even corrupt influence."[17] The second is the spirit of ultra-individualism which places private above public ends. The third is the insatiable desire to amass great wealth and to enjoy the material comforts of life. Great wealth has frequently been the stepping stone to social and political preferment. To ape the well-to-do in the exterior signs of comfort is with many a ruling passion. Happily, however, a reaction is well under way. The misuse of wealth has brought men of large means under suspicion. A large fortune has become a doubtful asset to a man seeking political advancement. The rising tide of idealism is saving us from moral degradation. The unscrupulous business man, labor leader and politician have antagonized the conscience and have aroused the public spirit of a nation. There is a stronger demand for moral earnestness in the public servant. The sins of the insurance companies helped to make Mr. Hughes governor of New York.

(*To be continued.*)

[17] "The American Commonwealth," edition of 1910, Vol. 1, p. 162.



DR. E. B. WILSON. DR. E. C. PICKERING.

Photograph taken at Atlanta of the president of the American Association, Dr. E. B. Wilson, professor of zoology, Columbia University, and of the retiring president, Dr. E. C. Pickering, director of the Harvard College Observatory.

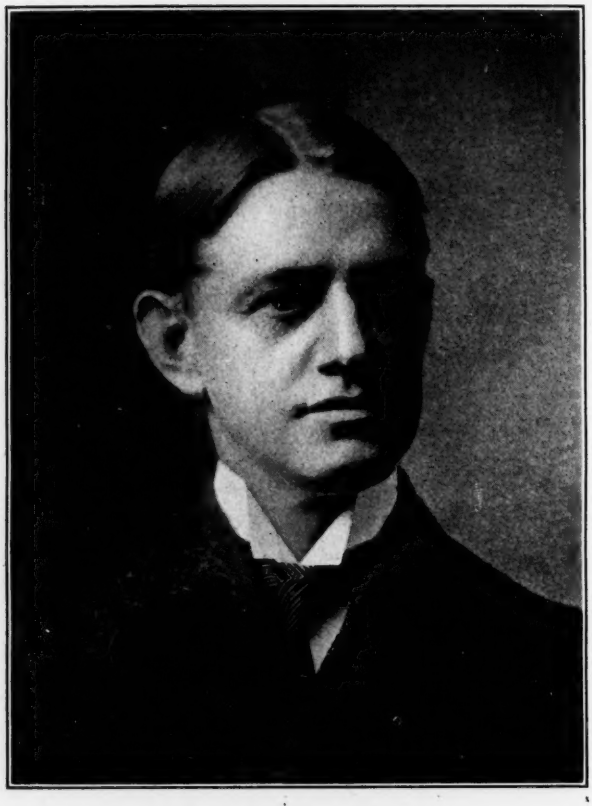
THE PROGRESS OF SCIENCE

THE ATLANTA MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE meeting at Atlanta was unusually pleasant for those who were able to be there. This is likely to be the case when the association meets at a distance from the larger scientific centers, for both the trip and the place are interesting and the welcome is cordial. Thus, for example, the name of the governor of the state is often on the program of the opening meeting, but he usually finds himself unable to be present on account of official business, whereas at Atlanta the governor and Mrs. Slaton gave a reception to the members at their home. At smaller meetings of the association, such as those at Denver, New Orleans and Atlanta, the members are not only likely to see more of their local hosts, but also to be more intimately thrown together outside the rooms of their meetings.

As a matter of fact the meeting at

DR. FRANK SCHLESINGER,
Vice-president for Mathematics and Astronomy, director of the Allegheny Observatory.



DR. ALFRED D. COLE,
Vice-president of the Section for Physics, professor of physics in Ohio State University.

Atlanta was of fair size. There were on the program 428 papers, distributed as follows:

Mathematics and astronomy.....	30
Physics	20
Chemistry	16
Engineering	31
Geology	34
Zoology and Entomology.....	111
Botany and Phytopathology.....	108
Anthropology, Psychology and Education	36
Economics and Social Science....	29
Physiology and Experimental Medicine	13
	428

As the national societies for botany and entomology met at Atlanta these sciences were well represented. Most of the national scientific societies held their meetings in the north, while the chemists now meet in the autumn. But it will be noted that each of the sciences had an adequate representation.

In addition to the technical papers containing accounts of research work, there were many addresses and several sessions of general interest, intended not for the specialist, but for those scientific men who care to know what is being accomplished in sciences other than their own and for the general public. The address of the president of the association, Dr. E. C. Pickering, director of the Harvard College Observatory, recounted the progress of the study of the stars, in which he and the observatory which he directs have had such an important share. The addresses of the vice-presidents for the sections were as follows:

Mathematics and Astronomy: "The Influence of Fourier's Series upon the

Development of Mathematics," by Edward B. Van Vleck, the University of Wisconsin.

Physics: "The Methods of Science: To What do they Apply?" by Arthur G. Webster, Clark University.

Mechanical Science and Engineering: "Safety and the Prevention of Waste in Mining and Metallurgical Operations," by J. A. Holmes, U. S. Bureau of Mines.

Geology and Geography: "Pleistocene History of Missouri River," by J. E. Todd, the University of Kansas.

Zoology: "The Story of Human Lineage," by William A. Locy, Northwestern University.

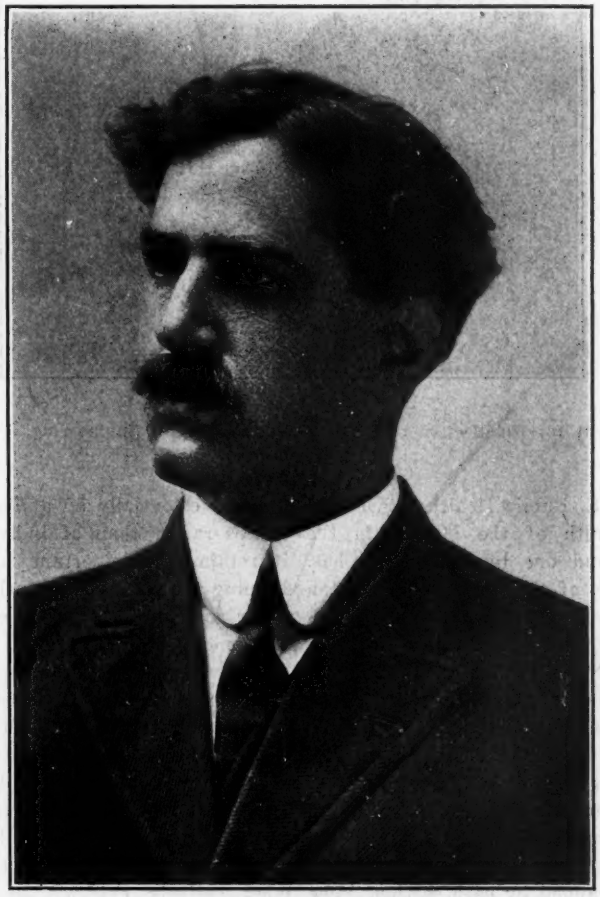
Botany: "The Evolution of a Botanical Problem," by Duncan S. Johnson, The Johns Hopkins University.

Social and Economic Science: "The Development of our Foreign Trade," by John Hays Hammond, New York City.

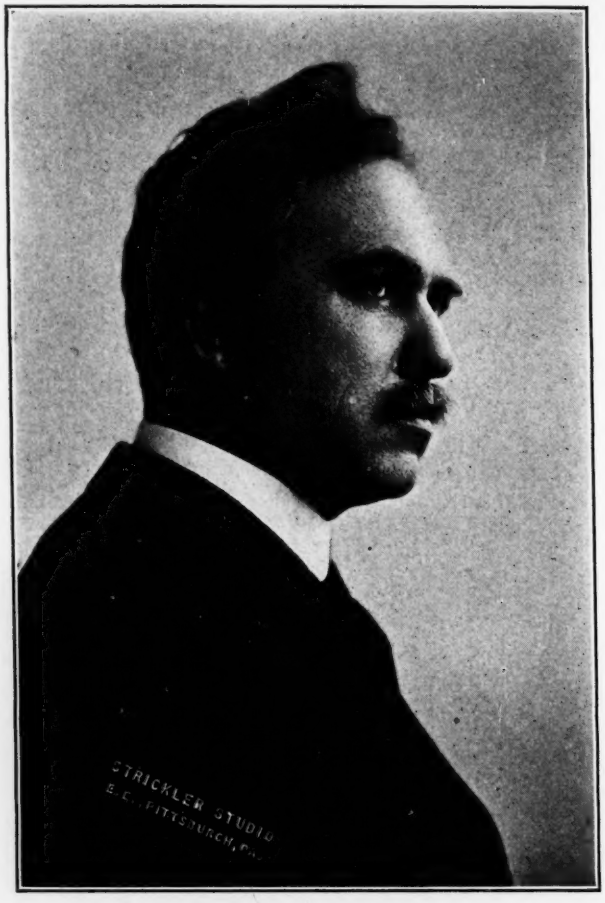
Physiology and Experimental Medicine: "The Physiological Instruction of Medical Students," by J. J. R. Macleod, Western Reserve University.

Education: "Science, Education and Democracy," by J. McKeen Cattell, Columbia University.

There were also given two public lectures complimentary to the citizens of Atlanta, one by Dr. Ch. Wardell Stiles,



DR. C. L. ALSBERG,
Vice-president for the Section of Chemistry, Chief of the Bureau of Chemistry, U. S. Department of Agriculture.



DR. O. P. HOOD,
Vice-president for the Section of Mechanical Science and Engineering, U. S. Bureau of Mines.

of the U. S. Public Health Service, on "The Health of the Mother in the South," and one by Professor Chas. E. Munroe, of the George Washington University on "The Explosive Resources of the Confederacy during the War and Now: A Chapter in Chemical History," each admirably adapted in subject matter and treatment to the occasion. The sections of the association do not have programs of technical papers when the ground is covered by a society meeting in affiliation with it. In that case programs of general interest are arranged by each section. The American Association is thus in respect to the research work of the special sciences essentially an affiliation of societies rather than of individuals, but it retains the important functions of keeping the sciences in touch with each other and representing science before the general public.

The MONTHLY is conservative in printing portraits of living men of science, but it aims to reproduce once a year the photographs of the president and vice-presidents of the association, as it seems desirable for as large a number as may be to become acquainted to this slight extent with those most actively engaged in advancing science in America. The officers elected at Atlanta continue the high traditions

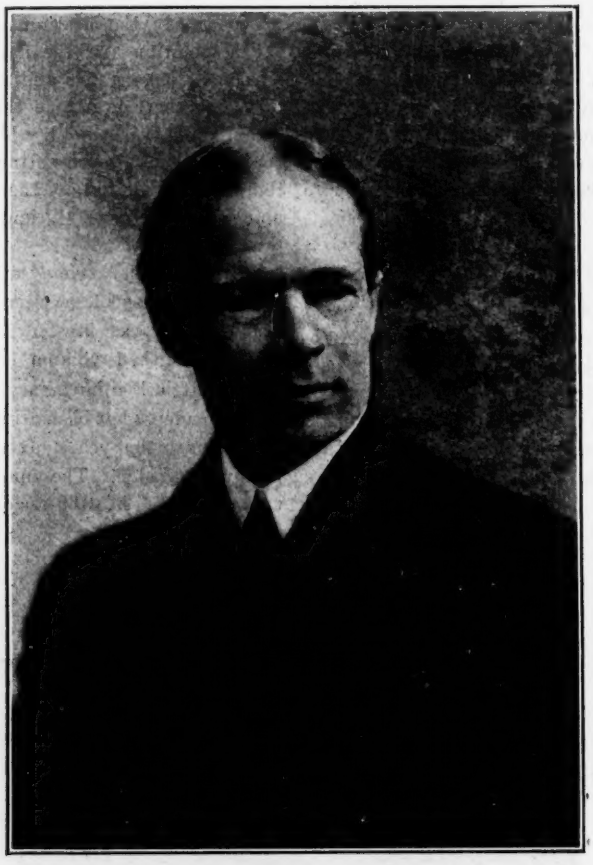
of the association. The section of education, not hitherto represented in the presidency, was able to provide a president of great distinction, Dr. Charles W. Eliot; emeritus president of Harvard University, once professor of chemistry, for more than forty years our leader in education.

THE WORK OF THE COUNCIL OF THE ASSOCIATION

THE council of the American Association is the body in this country best organized to advance the interests of science. It includes the past presidents of the association, who give a certain stability and dignity, but is otherwise an elected body, representing directly or indirectly the different sections of the association and the national scientific societies. Each affiliated society, of which there are some thirty, is represented in the council, which thus becomes a body representing the eight thousand members of the association and practically every scientific man of the country.

The National Academy of Sciences is by law the scientific adviser of the government, but, as is shown in the recently published volume commemorating its fiftieth anniversary, the advice of the academy has been asked only once in the past ten years, and the report was pigeon-holed. The fact is that the vast increase of the scientific work

DR. J. S. DILLER,
Vice-president of the Section for Geology and Geography, geologist, U. S. Geological Survey.



DR. HENRY C. COWLES,
Vice-president for the Section of Botany, professor of botany in the University of Chicago.

under the government provides it with scientific men in its employ competent to give advice, and the constitution and traditions of an academy composed of a small number of life members selected for distinction in research do not lead to great activity or efficiency. Thus several years ago a resolution endorsing the use of the metric system was defeated on the ground that the advice of the academy had not been asked.

The council of the American Association being an elected body representing all the scientific men and scientific activities of the country is in a better position to assume active leadership in movements for the advancement of science and the applications of science for the public welfare. Several such actions taken during the past years may be noted. At the spring meeting of the council a committee was appointed to confer with the president of the United States in regard to the heads of the scientific bureaus of the government and especially the chief of the Weather Bureau. The president received the committee courteously and the secretary of agriculture held a conference with the committee on policy of the association. This committee made subsequently certain recommendations in regard to the qualifications of heads of the scientific bureaus of the government and recommended that the National Academy of Sciences be requested

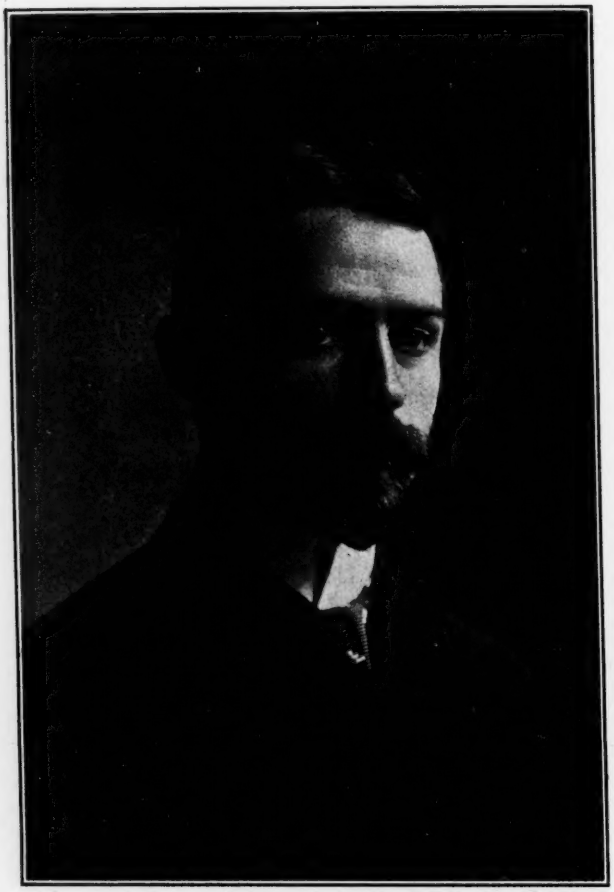
to appoint an official committee to advise the secretary of agriculture in regard to the chief of the Weather Bureau. This was done and the secretary of agriculture appointed Dr. Marvin, one of the three men endorsed by the committee of the academy. The secretary of agriculture would probably have made the same appointment without official scientific advice, though it is evident that this is a valuable safeguard.

Another instance of the usefulness of the council of the association is the committee on expert testimony appointed last year which made a preliminary report at Atlanta through Dr. E. C. Pickering and Dr. W. H. Holmes. The committee includes members of the association so eminent in their subjects as Dr. W. H. Welch in medicine, and Senator Elihu Root in law. It is a matter of public notoriety that the present methods of expert testimony in courts often defeat the ends of justice and bring science into disrepute. It is fortunate that we have a body so well fitted to attempt the reform of this procedure as the American Association.

The third action of the council which may be noted is the appointment of a committee of one hundred in research. Two sub-committees have already been organized, one to report on the existing research funds of the country and possible means of cooperation to increase their usefulness, the other on research in educational institutions which will make inquiries as to the extent to which research work by professors and instructors is encouraged in colleges and universities.

At Atlanta there were also adopted several plans looking to the increased

DR. THEODORE HOUGH,
Vice-president for Physiology, professor of physiology, University of Virginia.



DR. W. B. PILLSBURY,
Vice-president for Anthropology and Psychology, professor of psychology, University of Michigan.

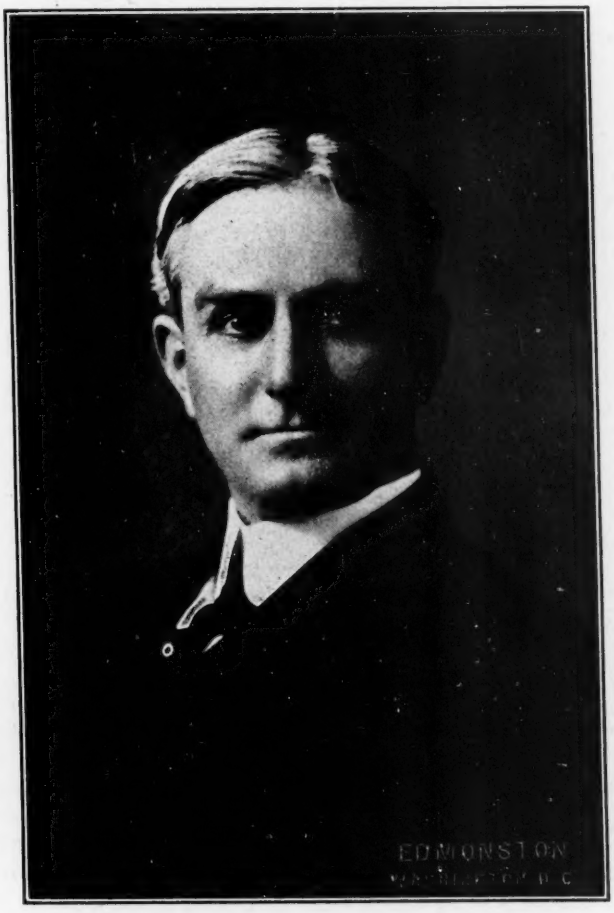
usefulness of the association. Reports were received in regard to the organization of the Pacific Coast Division, authorized a year ago, in view of the meeting of the association in California at the time of the Panama Exposition, but also empowered to hold independent meetings. The associate secretary for the south made a report on conditions in that region. A committee with Senor Eduardo Braga as chairman was formed with a view to the organization of a Brazilian division. If the association can become "American" in fact as well as in name, it will be a stimulus to science throughout the western hemisphere and a means of promoting goodwill among its republics. The establishment of local branches of the association was authorized in places where the members are prepared to conduct branches which will forward the objects of the association. This movement has possibilities of great development, especially in institutions and places somewhat remote from the large scientific centers where there are no academies of sciences or similar organizations. It was decided to arrange once in four years—in New York in 1916–17 and in Chicago in 1920–1—representative convocation-week meetings, in

which it is hoped that all the affiliated societies will unite so that the men of science of the whole country may be brought together and the importance and magnitude of their scientific work may serve as a stimulus to them and an impressive lesson to the general public.

THE ADDRESS OF THE PRESIDENT

In his presidential address before the association Professor Pickering stated that American universities and colleges devoted a hundred times as much time and money to diffusing human knowledge as to the object of the American Association of Science. The greatest need of science at the present time is the means for aiding the real men of genius.

The first catalogue of the stars was made by Hipparchus two thousand years ago. A thousand years later it was revised by a Persian astronomer Sûfi. They show not only that the positions and brightness of the stars have changed but little in two thousand years, but that the same may be said of the sensitiveness of the human eye to lights of different colors. The places of the stars were first accurately deter-



DR. P. P. CLAXTON,
Vice-president for Education, U. S. Commissioner of Education.

mined a century and a half ago, but the chronograph, known for many years as the American method, is only half a century old.

One of the greatest astronomical researches has been the measurement of the exact positions of 166,000 stars. The sky was divided into twenty zones of which seven were taken by Germany, four by the United States and three by Russia. Of the American zones two were observed at Cambridge, one at Albany, and one at Washington. Each occupied the time of several astronomers for twenty years. It is now nearly time, after fifty years, to reobserve these stars to determine their motions. Fortunately, two new methods, the transit micrometer and photography, have been found which will greatly reduce the labor. The older department of astronomy, measuring the positions of the stars, has been left in America to the Naval Observatory. Unfortunately, the law requires that the superintendent must be a naval officer who can not remain long on land. The average term of office is less than two years. The average term at Greenwich is thirty years, where with but half the income, more than double the work is done. Congress, though repeatedly appealed to, will not remedy this great waste of the public funds.

Two million measures of the light of 80,000 stars have been made at Harvard. The results have been accepted by an international committee as the standard for the world. Such measures are likely in the future to be replaced by photographs taken with yellow light. A certain class of stars vary in brightness. Some increase in light many thousand times, others double their brightness in seven minutes with perfect regularity. Many thousand excellent observations of these objects are now obtained every year by amateurs having only small telescopes. Nearly five thousand variable stars are known of which three quarters have been found at Harvard. Astronomical photography, and American invention, replaces eye observations in almost all researches. Two Harvard telescopes have each taken 40,000 photographs whose combined weight is about forty tons. They give the only record on the earth of the history of the stars for the last quarter of a century. Photographs of the spectra of the stars to determine their motions form the principal work of the Lick, Yerkes, Greenwich, Potsdam and many other of the larger observatories. A catalogue of the spectra of 200,000 stars is now being compiled at Harvard, and will fill seven large quarto volumes.

The friendly cooperation of American astronomers has greatly advanced the work in this country, but it will be difficult to compete with the splendid observatories and instruments now lavishly furnished in Germany. If similar support is given us, the American Association for the Advancement of Science can fulfill its objects as regards astronomy.

SCIENTIFIC ITEMS

SCIENCE in America has during the past month lost three of its most distinguished leaders—Dr. S. Weir Mitchell, the eminent physician, physiologist and man of letters, of Philadelphia; Dr. Seth C. Chandler, the astronomer of Cambridge, and Dr. Benjamin Osgood Peirce, Hollis professor of mathematics and natural philosophy at Harvard University.

DR. CHARLES BUDD ROBINSON, economic botanist of the Bureau of Science of the Philippine Islands has been killed by natives in the Amboyna Islands in the Malay Archipelago.

IT is proposed to place a suitable memorial of the late Alfred Russel Wallace in Westminster Abbey. It is also proposed to present a statue or bust to the British Museum of Natural History and a portrait to the Royal Society. Contributions to the Alfred Russel Wallace Memorial Fund may be sent to the London and Smith Bank, Holborn Circus, London, E.C.